Model Year 2017 Green Vehicle Guide

(Limited to releasable data submitted earlier than 02/15/2017)

Model	Displ	Cyl	Trans	Drive	Fuel	Cert Region	Stnd	Stnd Description	Underhood ID	Veh Class	Air Pollution Score	City MPG	Hwy MPG	Cmb MPG	Greenhouse Gas Score	SmartWay	Comb CO2
MINI Cooper S Clubman	2	4	Man-6	4WD	Gasoline	CA	L3SULEV30/PZEV	California LEV-III SULEV30/PZEV	HBMXV02.0M46	midsize car	9	21	30	24	5	No	366
MINI Cooper S Clubman	2	4	Man-6	4WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HBMXV02.0M46	midsize car	8	21	30	24	5	No	366
MINI Cooper S Clubman	2	4	SemiAuto-8	4WD	Gasoline	CA	L3SULEV30/PZEV	California LEV-III SULEV30/PZEV	HBMXV02.0M46	midsize car	9	22	31	26	6	No	346
MINI Cooper S Clubman	2	4	SemiAuto-8	4WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HBMXV02.0M46	midsize car	8	22	31	26	6	No	346
MINI Cooper S Convertible	2	4	Man-6	2WD	Gasoline	CA	L3SULEV30/PZEV	California LEV-III SULEV30/PZEV	HBMXV02.0M46	small car	9	23	32	26	6	No	337
MINI Cooper S Convertible	2	4	Man-6	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HBMXV02.0M46	small car	8	23	32	26	6	No	337
MINI Cooper S Convertible	2	4	SemiAuto-6	2WD	Gasoline	CA	L3SULEV30/PZEV	California LEV-III SULEV30/PZEV	HBMXV02.0M46	small car	9	25	33	28	6	No	315
MINI Cooper S Convertible	2	4	SemiAuto-6	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HBMXV02.0M46	small car	8	25	33	28	6	No	315
MINI Cooper S Hardtop	2	4	Man-6	2WD	Gasoline	CA	L3SULEV30/PZEV	California LEV-III SULEV30/PZEV	HBMXV02.0M46	small car	9	23	32	26	6	No	337
MINI Cooper S Hardtop	2	4	Man-6	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HBMXV02.0M46	small car	8	23	32	26	6	No	337
MINI Cooper S Hardtop	2	4	SemiAuto-6	2WD	Gasoline	CA	L3SULEV30/PZEV	California LEV-III SULEV30/PZEV	HBMXV02.0M46	small car	9	25	32	28	6	No	316
MINI Cooper S Hardtop	2	4	SemiAuto-6	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HBMXV02.0M46	small car	8	25	32	28	6	No	316
MINI Countryman All4	1.5	4	Man-6	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HBMXV01.5M3X	midsize car	6	22	32	26	6	No	345
MINI Countryman All4	1.5	4	Man-6	4WD	Gasoline	CA	U2	California LEV-II ULEV	HBMXV01.5M3X	midsize car	6	22	32	26	6	No	345
MINI John Cooper Works Clubman All4	2	4	Man-6	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HBMXV02.0M48	midsize car	6	21	31	24	5	No	367
MINI John Cooper Works Clubman All4	2	4	Man-6	4WD	Gasoline	CA	U2	California LEV-II ULEV	HBMXV02.0M48	midsize car	6	21	31	24	5	No	367
MINI John Cooper Works Clubman All4	2	4	SemiAuto-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HBMXV02.0M48	midsize car	6	23	31	26	6	No	339
MINI John Cooper Works Clubman All4	2	4	SemiAuto-8	4WD	Gasoline	CA	U2	California LEV-II ULEV	HBMXV02.0M48	midsize car	6	23	31	26	6	No	339
MINI John Cooper Works Convertible	2	4	Man-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HBMXV02.0M48	small car	6	22	31	25	5	No	349
MINI John Cooper Works Convertible	2	4	Man-6	2WD	Gasoline	CA	U2	California LEV-II ULEV	HBMXV02.0M48	small car	6	22	31	25	5	No	349
MINI John Cooper Works Convertible	2	4	SemiAuto-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HBMXV02.0M48	small car	6	24	32	27	6	No	327
MINI John Cooper Works Convertible	2	4	SemiAuto-6	2WD	Gasoline	CA	U2	California LEV-II ULEV	HBMXV02.0M48	small car	6	24	32	27	6	No	327

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Model	Displ	Cyl	Trans	Drive	Fuel	Cert Region	Stnd	Stnd Description	Underhood ID	Veh Class	Air Pollution Score	City MPG	Hwy MPG	Cmb MPG	Greenhouse Gas Score	SmartWay	Comb CO2
MINI John Cooper Works Hardtop	2	4	Man-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HBMXV02.0M48	small car	6	23	32	26	6	No	337
MINI John Cooper Works Hardtop	2	4	Man-6	2WD	Gasoline	CA	U2	California LEV-II ULEV	HBMXV02.0M48	small car	6	23	32	26	6	No	337
MINI John Cooper Works Hardtop	2	4	SemiAuto-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HBMXV02.0M48	small car	6	25	32	28	6	No	316
MINI John Cooper Works Hardtop	2	4	SemiAuto-6	2WD	Gasoline	CA	U2	California LEV-II ULEV	HBMXV02.0M48	small car	6	25	32	28	6	No	316
MITSUBISHI Lancer	2	4	Man-5	2WD	Gasoline	CA	L2	California LEV-II LEV	HMTXV02.4G9X	small car	5	24	33	28	6	No	322
MITSUBISHI Lancer	2	4	Man-5	2WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HMTXV02.4G9X	small car	5	24	33	28	6	No	322
MITSUBISHI Lancer	2	4	SCV-6	2WD	Gasoline	CA	L2	California LEV-II LEV	HMTXV02.4G9X	small car	5	27	34	30	7	Yes	295
MITSUBISHI Lancer	2	4	SCV-6	2WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HMTXV02.4G9X	small car	5	27	34	30	7	Yes	295
MITSUBISHI Lancer	2.4	4	SCV-6	4WD	Gasoline	CA	L2	California LEV-II LEV	HMTXV02.4G9X	small car	5	23	30	26	6	No	343
MITSUBISHI Lancer	2.4	4	SCV-6	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HMTXV02.4G9X	small car	5	23	30	26	6	No	343
MITSUBISHI Mirage	1.2	3	CVT	2WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HMTXV01.2G5P	small car	7	37	43	39	9	Yes	226
MITSUBISHI Mirage	1.2	3	CVT	2WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HMTXV01.2G5P	small car	7	37	43	39	9	Yes	226
MITSUBISHI Mirage	1.2	3	Man-5	2WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HMTXV01.2G5P	small car	7	33	41	36	8	Yes	242
MITSUBISHI Mirage	1.2	3	Man-5	2WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HMTXV01.2G5P	small car	7	33	41	36	8	Yes	242
MITSUBISHI Mirage G4	1.2	3	CVT	2WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HMTXV01.2G5P	small car	7	35	42	37	8	Yes	237
MITSUBISHI Mirage G4	1.2	3	CVT	2WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HMTXV01.2G5P	small car	7	35	42	37	8	Yes	237
MITSUBISHI Mirage G4	1.2	3	Man-5	2WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HMTXV01.2G5P	small car	7	33	40	35	8	Yes	249
MITSUBISHI Mirage G4	1.2	3	Man-5	2WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HMTXV01.2G5P	small car	7	33	40	35	8	Yes	249
MITSUBISHI Outlander	2.4	4	SCV-6	2WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HMTXT02.4G5Y	small SUV	7	25	30	27	6	No	330
MITSUBISHI Outlander	2.4	4	SCV-6	2WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HMTXT02.4G5Y	small SUV	7	25	30	27	6	No	330
MITSUBISHI Outlander	2.4	4	SCV-6	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HMTXT02.4G5Y	small SUV	7	24	29	26	6	No	340
MITSUBISHI Outlander	2.4	4	SCV-6	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HMTXT02.4G5Y	small SUV	7	24	29	26	6	No	340
MITSUBISHI Outlander	3	6	SemiAuto-6	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HMTXT03.0G5P	small SUV	7	20	27	23	5	No	388
MITSUBISHI Outlander	3	6	SemiAuto-6	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HMTXT03.0G5P	small SUV	7	20	27	23	5	No	388
MITSUBISHI Outlander Sport	2	4	Man-5	2WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HMTXT02.0G5P	small SUV	7	23	29	25	5	No	347
MITSUBISHI Outlander Sport	2	4	Man-5	2WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HMTXT02.0G5P	small SUV	7	23	29	25	5	No	347

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MITSUBISHI Outlander Sport	2	4	SCV-6	2WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HMTXT02.0G5P	small SUV	7	24	30	27	6	No	328
MITSUBISHI Outlander Sport	2	4	SCV-6	2WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HMTXT02.0G5P	small SUV	7	24	30	27	6	No	328
MITSUBISHI Outlander Sport	2	4	SCV-6	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HMTXT02.0G5P	small SUV	7	23	29	26	6	No	343
MITSUBISHI Outlander Sport	2	4	SCV-6	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HMTXT02.0G5P	small SUV	7	23	29	26	6	No	343
MITSUBISHI Outlander Sport	2.4	4	SCV-6	2WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HMTXT02.4G5P	small SUV	7	23	28	25	5	No	355
MITSUBISHI Outlander Sport	2.4	4	SCV-6	2WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HMTXT02.4G5P	small SUV	7	23	28	25	5	No	355
MITSUBISHI Outlander Sport	2.4	4	SCV-6	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HMTXT02.4G5P	small SUV	7	22	27	24	5	No	368
MITSUBISHI Outlander Sport	2.4	4	SCV-6	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HMTXT02.4G5P	small SUV	7	22	27	24	5	No	368
MITSUBISHI i-MiEV	N/A	N/A	Auto-1	2WD	Electricity	FA	T3B0	Federal Tier 3 Bin 0	HMTXV00.0E1T	small car	10	121	102	112	10	Elite	0
MITSUBISHI i-MiEV	N/A	N/A	Auto-1	2WD	Electricity	CA	ZEV	California ZEV	HMTXV00.0E1T	small car	10	121	102	112	10	Elite	0
McLAREN 570GT	3.8	8	Auto-7	2WD	Gasoline	CA	L2	California LEV-II LEV	HMLNV03.8M13	small car	5	16	23	19	4	No	481
McLAREN 570GT	3.8	8	Auto-7	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HMLNV03.8M13	small car	6	16	23	19	4	No	481
McLAREN 570S Coupe	3.8	8	Auto-7	2WD	Gasoline	CA	L2	California LEV-II LEV	HMLNV03.8M13	small car	5	16	23	19	4	No	481
McLAREN 570S Coupe	3.8	8	Auto-7	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HMLNV03.8M13	small car	6	16	23	19	4	No	481
NISSAN 370Z	3.7	6	Man-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXV03.7NAA	small car	6	18	26	21	4	No	426
NISSAN 370Z	3.7	6	Man-6	2WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXV03.7NAA	small car	6	18	26	21	4	No	426
NISSAN 370Z	3.7	6	SemiAuto-7	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXV03.7NAA	small car	6	19	26	22	5	No	411
NISSAN 370Z	3.7	6	SemiAuto-7	2WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXV03.7NAA	small car	6	19	26	22	5	No	411
NISSAN 370Z Roadster	3.7	6	Man-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXV03.7NAA	small car	6	17	24	20	4	No	447
NISSAN 370Z Roadster	3.7	6	Man-6	2WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXV03.7NAA	small car	6	17	24	20	4	No	447
NISSAN 370Z Roadster	3.7	6	SemiAuto-7	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXV03.7NAA	small car	6	18	25	21	4	No	433
NISSAN 370Z Roadster	3.7	6	SemiAuto-7	2WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXV03.7NAA	small car	6	18	25	21	4	No	433
NISSAN Altima	2.5	4	CVT	2WD	Gasoline	CA	L3SULEV30	California LEV-III SULEV30	HNSXV02.5R5A	midsize car	8	27	39	31	7	Yes	287
NISSAN Altima	2.5	4	CVT	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HNSXV02.5R5A	midsize car	8	27	39	31	7	Yes	287
NISSAN Altima	3.5	6	SCV-7	2WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HNSXV03.5N7A	midsize car	6	22	32	26	6	No	347
NISSAN Altima	3.5	6	SCV-7	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXV03.5N7A	midsize car	6	22	32	26	6	No	347
NISSAN Altima SR	2.5	4	SCV-7	2WD	Gasoline	CA	L3SULEV30	California LEV-III SULEV30	HNSXV02.5R5A	midsize car	8	26	37	30	7	Yes	297
NISSAN Altima SR	2.5	4	SCV-7	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HNSXV02.5R5A	midsize car	8	26	37	30	7	Yes	297
NISSAN Armada	5.6	8	SemiAuto-7	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXT05.6N9A	standard SUV	6	14	19	16	2	No	555

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NISSAN Armada	5.6	8	SemiAuto-7	2WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXT05.6N9A	standard SUV	6	14	19	16	2	No	555
NISSAN Armada	5.6	8	SemiAuto-7	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXT05.6N9A	standard SUV	6	13	18	15	2	No	588
NISSAN Armada	5.6	8	SemiAuto-7	4WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXT05.6N9A	standard SUV	6	13	18	15	2	No	588
NISSAN Frontier	2.5	4	Auto-5	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXT02.5N5A	pickup	6	17	22	19	4	No	467
NISSAN Frontier	2.5	4	Auto-5	2WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXT02.5N5A	pickup	6	17	22	19	4	No	467
NISSAN Frontier	2.5	4	Man-5	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXT02.5N5A	pickup	6	19	23	21	4	No	431
NISSAN Frontier	2.5	4	Man-5	2WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXT02.5N5A	pickup	6	19	23	21	4	No	431
NISSAN Frontier	4	6	Auto-5	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXT04.0N6A	pickup	6	16	23	19	4	No	478
NISSAN Frontier	4	6	Auto-5	2WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXT04.0N6A	pickup	6	16	23	19	4	No	478
NISSAN Frontier	4	6	Auto-5	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXT04.0N6A	pickup	6	15	21	17	3	No	520
NISSAN Frontier	4	6	Auto-5	4WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXT04.0N6A	pickup	6	15	21	17	3	No	520
NISSAN Frontier	4	6	Man-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXT04.0N6A	pickup	6	16	22	19	4	No	479
NISSAN Frontier	4	6	Man-6	2WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXT04.0N6A	pickup	6	16	22	19	4	No	479
NISSAN Frontier	4	6	Man-6	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXT04.0N6A	pickup	6	16	21	18	3	No	507
NISSAN Frontier	4	6	Man-6	4WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXT04.0N6A	pickup	6	16	21	18	3	No	507
NISSAN Frontier FFV	4	6	Auto-5	2WD	Ethanol/Gas	FA	T3B125	Federal Tier 3 Bin 125	HNSXT04.0N6B	pickup	6	11/16	16/22	13/18	3	No	471/494
NISSAN Frontier FFV	4	6	Auto-5	4WD	Ethanol/Gas	FA	T3B125	Federal Tier 3 Bin 125	HNSXT04.0N6B	pickup	6	11/15	15/21	12/17	3	No	504/521
NISSAN GT-R	3.8	6	AutoMan-6	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXV03.8NBA	small car	6	16	22	18	3	No	484
NISSAN GT-R	3.8	6	AutoMan-6	4WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXV03.8NBA	small car	6	16	22	18	3	No	484
NISSAN Juke	1.6	4	Man-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXV01.6NDA	station wagon	6	27	33	29	7	Yes	307
NISSAN Juke	1.6	4	Man-6	2WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXV01.6NDA	station wagon	6	27	33	29	7	Yes	307
NISSAN Juke	1.6	4	SCV-7	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXV01.6NDA	station wagon	6	28	32	29	7	Yes	303
NISSAN Juke	1.6	4	SCV-7	2WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXV01.6NDA	station wagon	6	28	32	29	7	Yes	303
NISSAN Juke	1.6	4	SCV-7	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXV01.6NDA	station wagon	6	26	30	28	6	No	319
NISSAN Juke	1.6	4	SCV-7	4WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXV01.6NDA	station wagon	6	26	30	28	6	No	319
NISSAN Juke Nismo RS	1.6	4	Man-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXV01.6NDB	station wagon	6	26	31	28	6	No	316
NISSAN Juke Nismo RS	1.6	4	Man-6	2WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXV01.6NDB	station wagon	6	26	31	28	6	No	316
NISSAN Juke Nismo RS	1.6	4	SCV-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXV01.6NDB	station wagon	6	25	29	26	6	No	337
NISSAN Juke Nismo RS	1.6	4	SCV-8	4WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXV01.6NDB	station wagon	6	25	29	26	6	No	337
NISSAN Leaf	N/A	N/A	Auto-1	2WD	Electricity	FA	T3B0	Federal Tier 3 Bin 0	HNSXV0000LLB	midsize car	10	124	101	112	10	Elite	0

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NISSAN Leaf	N/A	N/A	Auto-1	2WD	Electricity	CA	ZEV	California ZEV	HNSXV0000LLB	midsize car	10	124	101	112	10	Elite	0
NISSAN Maxima	3.5	6	SCV-7	2WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HNSXV03.5N7B	midsize car	6	21	30	25	5	No	366
NISSAN Maxima	3.5	6	SCV-7	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXV03.5N7B	midsize car	6	21	30	25	5	No	366
NISSAN Murano	3.5	6	SCV-7	2WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HNSXV03.5P7C	station wagon	7	21	28	24	5	No	373
NISSAN Murano	3.5	6	SCV-7	2WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HNSXV03.5P7C	station wagon	7	21	28	24	5	No	373
NISSAN Murano	3.5	6	SCV-7	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HNSXV03.5P7C	station wagon	7	21	28	24	5	No	376
NISSAN Murano	3.5	6	SCV-7	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HNSXV03.5P7C	station wagon	7	21	28	24	5	No	376
NISSAN NV200	2	4	CVT	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXT02.0N2A	special purpose	6	24	26	25	5	No	354
NISSAN NV200	2	4	CVT	2WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXT02.0N2A	special purpose	6	24	26	25	5	No	354
NISSAN Pathfinder	3.5	6	CVT	2WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HNSXT03.5P7A	small SUV	7	20	27	23	5	No	395
NISSAN Pathfinder	3.5	6	CVT	2WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HNSXT03.5P7A	small SUV	7	20	27	23	5	No	395
NISSAN Pathfinder	3.5	6	CVT	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HNSXT03.5P7A	small SUV	7	19	26	22	5	No	404
NISSAN Pathfinder	3.5	6	CVT	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HNSXT03.5P7A	small SUV	7	19	26	22	5	No	404
NISSAN Pathfinder 4WD Platinum	3.5	6	CVT	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HNSXT03.5N7B	small SUV	6	19	26	21	4	No	415
NISSAN Pathfinder 4WD Platinum	3.5	6	CVT	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXT03.5N7B	small SUV	6	19	26	21	4	No	415
NISSAN Quest	3.5	6	CVT	2WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HNSXT03.5N7A	minivan	6	20	27	22	5	No	396
NISSAN Quest	3.5	6	CVT	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXT03.5N7A	minivan	6	20	27	22	5	No	396
NISSAN Rogue	2.5	4	CVT	2WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HNSXT02.5P5A	small SUV	7	26	33	29	7	Yes	312
NISSAN Rogue	2.5	4	CVT	2WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HNSXT02.5P5A	small SUV	7	26	33	29	7	Yes	312
NISSAN Rogue	2.5	4	CVT	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HNSXT02.5P5A	small SUV	7	25	32	27	6	No	326
NISSAN Rogue	2.5	4	CVT	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HNSXT02.5P5A	small SUV	7	25	32	27	6	No	326
NISSAN Rogue Hybrid	2	4	SCV-7	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXT02.0NGA	small SUV	6	33	35	34	8	Yes	261
NISSAN Rogue Hybrid	2	4	SCV-7	2WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXT02.0NGA	small SUV	6	33	35	34	8	Yes	261
NISSAN Rogue Hybrid	2	4	SCV-7	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXT02.0NGA	small SUV	6	31	34	33	8	Yes	276
NISSAN Rogue Hybrid	2	4	SCV-7	4WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXT02.0NGA	small SUV	6	31	34	33	8	Yes	276
NISSAN Sentra	1.6	4	Man-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXV01.6NDA	midsize car	6	26	32	28	6	No	318
NISSAN Sentra	1.6	4	Man-6	2WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXV01.6NDA	midsize car	6	26	32	28	6	No	318
NISSAN Sentra	1.6	4	SCV-7	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXV01.6NDA	midsize car	6	27	33	29	7	Yes	307
NISSAN Sentra	1.6	4	SCV-7	2WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXV01.6NDA	midsize car	6	27	33	29	7	Yes	307
NISSAN Sentra	1.8	4	CVT	2WD	Gasoline	CA	L3SULEV30	California LEV-III SULEV30	HNSXV01.8R1A	midsize car	8	29	37	32	7	Yes	278

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Model	Displ	Cyl	Trans	Drive	Fuel	Cert Region	Stnd	Stnd Description	Underhood ID	Veh Class	Air Pollution Score	City MPG	Hwy MPG	Cmb MPG	Greenhouse Gas Score	SmartWay	Comb CO2
NISSAN Sentra	1.8	4	CVT	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HNSXV01.8R1A	midsize car	8	29	37	32	7	Yes	278
NISSAN Sentra	1.8	4	Man-6	2WD	Gasoline	CA	L2	California LEV-II LEV	HNSXV01.8M1A	midsize car	5	27	35	30	7	Yes	298
NISSAN Sentra	1.8	4	Man-6	2WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HNSXV01.8M1A	midsize car	5	27	35	30	7	Yes	298
NISSAN Sentra Nismo	1.6	4	Man-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXV01.6NDA	midsize car	6	25	31	27	6	No	330
NISSAN Sentra Nismo	1.6	4	Man-6	2WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXV01.6NDA	midsize car	6	25	31	27	6	No	330
NISSAN Sentra Nismo	1.6	4	SCV-7	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXV01.6NDA	midsize car	6	25	30	27	6	No	330
NISSAN Sentra Nismo	1.6	4	SCV-7	2WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXV01.6NDA	midsize car	6	25	30	27	6	No	330
NISSAN Titan	5.6	8	SemiAuto-7	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXT05.6N9A	pickup	6	15	21	18	3	No	505
NISSAN Titan	5.6	8	SemiAuto-7	2WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXT05.6N9A	pickup	6	15	21	18	3	No	505
NISSAN Titan	5.6	8	SemiAuto-7	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXT05.6N9A	pickup	6	15	21	18	3	No	505
NISSAN Titan	5.6	8	SemiAuto-7	4WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXT05.6N9A	pickup	6	15	21	18	3	No	505
NISSAN Titan Pro-4X	5.6	8	SemiAuto-7	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXT05.6N9A	pickup	6	15	20	17	3	No	529
NISSAN Titan Pro-4X	5.6	8	SemiAuto-7	4WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXT05.6N9A	pickup	6	15	20	17	3	No	529
NISSAN Versa	1.6	4	Auto-4	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXV01.6N4A	small car	6	26	35	29	7	Yes	302
NISSAN Versa	1.6	4	Auto-4	2WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXV01.6N4A	small car	6	26	35	29	7	Yes	302
NISSAN Versa	1.6	4	CVT	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXV01.6N4A	small car	6	31	39	34	8	Yes	260
NISSAN Versa	1.6	4	CVT	2WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXV01.6N4A	small car	6	31	39	34	8	Yes	260
NISSAN Versa	1.6	4	Man-5	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HNSXV01.6N4A	small car	6	27	36	30	7	Yes	296
NISSAN Versa	1.6	4	Man-5	2WD	Gasoline	CA	U2	California LEV-II ULEV	HNSXV01.6N4A	small car	6	27	36	30	7	Yes	296
PORSCHE 911 Carrera	3	6	AMS-7	2WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	22	30	25	5	No	355
PORSCHE 911 Carrera	3	6	AMS-7	2WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	22	30	25	5	No	355
PORSCHE 911 Carrera	3	6	Man-7	2WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	20	29	23	5	No	382
PORSCHE 911 Carrera	3	6	Man-7	2WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	20	29	23	5	No	382
PORSCHE 911 Carrera 4	3	6	AMS-7	4WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	22	28	24	5	No	362
PORSCHE 911 Carrera 4	3	6	AMS-7	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	22	28	24	5	No	362
PORSCHE 911 Carrera 4	3	6	Man-7	4WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	20	28	23	5	No	389
PORSCHE 911 Carrera 4	3	6	Man-7	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	20	28	23	5	No	389
PORSCHE 911 Carrera 4 Cabriolet	3	6	AMS-7	4WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	21	28	24	5	No	370
PORSCHE 911 Carrera 4 Cabriolet	3	6	AMS-7	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	21	28	24	5	No	370
PORSCHE 911 Carrera 4 Cabriolet	3	6	Man-7	4WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	19	28	22	5	No	395
PORSCHE 911 Carrera 4 Cabriolet	3	6	Man-7	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	19	28	22	5	No	395
PORSCHE 911 Carrera 4 GTS	3	6	AMS-7	4WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	20	26	22	5	No	400
PORSCHE 911 Carrera 4 GTS	3	6	AMS-7	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	20	26	22	5	No	400

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PORSCHE 911 Carrera 4 GTS	3	6	Man-7	4WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	18	26	21	4	No	414
PORSCHE 911 Carrera 4 GTS	3	6	Man-7	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	18	26	21	4	No	414
PORSCHE 911 Carrera 4 GTS Cabriolet	3	6	AMS-7	4WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	20	25	22	5	No	402
PORSCHE 911 Carrera 4 GTS Cabriolet	3	6	AMS-7	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	20	25	22	5	No	402
PORSCHE 911 Carrera 4 GTS Cabriolet	3	6	Man-7	4WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	18	26	21	4	No	419
PORSCHE 911 Carrera 4 GTS Cabriolet	3	6	Man-7	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	18	26	21	4	No	419
PORSCHE 911 Carrera 4S	3	6	AMS-7	4WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	21	28	24	5	No	373
PORSCHE 911 Carrera 4S	3	6	AMS-7	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	21	28	24	5	No	373
PORSCHE 911 Carrera 4S	3	6	Man-7	4WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	20	28	23	5	No	392
PORSCHE 911 Carrera 4S	3	6	Man-7	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	20	28	23	5	No	392
PORSCHE 911 Carrera 4S Cabriolet	3	6	AMS-7	4WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	21	28	24	5	No	371
PORSCHE 911 Carrera 4S Cabriolet	3	6	AMS-7	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	21	28	24	5	No	371
PORSCHE 911 Carrera 4S Cabriolet	3	6	Man-7	4WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	19	28	22	5	No	396
PORSCHE 911 Carrera 4S Cabriolet	3	6	Man-7	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	19	28	22	5	No	396
PORSCHE 911 Carrera Cabriolet	3	6	AMS-7	2WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	22	28	24	5	No	365
PORSCHE 911 Carrera Cabriolet	3	6	AMS-7	2WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	22	28	24	5	No	365
PORSCHE 911 Carrera Cabriolet	3	6	Man-7	2WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	20	29	23	5	No	388
PORSCHE 911 Carrera Cabriolet	3	6	Man-7	2WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	20	29	23	5	No	388
PORSCHE 911 Carrera GTS	3	6	AMS-7	2WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	20	26	23	5	No	391
PORSCHE 911 Carrera GTS	3	6	AMS-7	2WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	20	26	23	5	No	391
PORSCHE 911 Carrera GTS	3	6	Man-7	2WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	18	26	21	4	No	418
PORSCHE 911 Carrera GTS	3	6	Man-7	2WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	18	26	21	4	No	418

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PORSCHE 911 Carrera GTS Cabriolet	3	6	AMS-7	2WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	20	26	22	5	No	400
PORSCHE 911 Carrera GTS Cabriolet	3	6	AMS-7	2WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	20	26	22	5	No	400
PORSCHE 911 Carrera GTS Cabriolet	3	6	Man-7	2WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	18	26	21	4	No	415
PORSCHE 911 Carrera GTS Cabriolet	3	6	Man-7	2WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	18	26	21	4	No	415
PORSCHE 911 Carrera S	3	6	AMS-7	2WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	22	28	24	5	No	363
PORSCHE 911 Carrera S	3	6	AMS-7	2WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	22	28	24	5	No	363
PORSCHE 911 Carrera S	3	6	Man-7	2WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	20	29	23	5	No	389
PORSCHE 911 Carrera S	3	6	Man-7	2WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	20	29	23	5	No	389
PORSCHE 911 Carrera S Cabriolet	3	6	AMS-7	2WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	22	28	24	5	No	367
PORSCHE 911 Carrera S Cabriolet	3	6	AMS-7	2WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	22	28	24	5	No	367
PORSCHE 911 Carrera S Cabriolet	3	6	Man-7	2WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	20	28	23	5	No	391
PORSCHE 911 Carrera S Cabriolet	3	6	Man-7	2WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	20	28	23	5	No	391
PORSCHE 911 Targa 4	3	6	AMS-7	4WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	22	28	24	5	No	367
PORSCHE 911 Targa 4	3	6	AMS-7	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	22	28	24	5	No	367
PORSCHE 911 Targa 4	3	6	Man-7	4WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	19	28	22	5	No	395
PORSCHE 911 Targa 4	3	6	Man-7	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	19	28	22	5	No	395
PORSCHE 911 Targa 4 GTS	3	6	AMS-7	4WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	20	26	22	5	No	404
PORSCHE 911 Targa 4 GTS	3	6	AMS-7	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	20	26	22	5	No	404
PORSCHE 911 Targa 4 GTS	3	6	Man-7	4WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	18	26	21	4	No	428
PORSCHE 911 Targa 4 GTS	3	6	Man-7	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	18	26	21	4	No	428
PORSCHE 911 Targa 4S	3	6	AMS-7	4WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	21	27	24	5	No	376
PORSCHE 911 Targa 4S	3	6	AMS-7	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	21	27	24	5	No	376
PORSCHE 911 Targa 4S	3	6	Man-7	4WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXV03.0C91	small car	5	19	28	22	5	No	396

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Model	Displ	Cyl	Trans	Drive	Fuel	Cert Region	Stnd	Stnd Description	Underhood ID	Veh Class	Air Pollution Score	City MPG	Hwy MPG	Cmb MPG	Greenhouse Gas Score	SmartWay	Comb CO2
PORSCHE 911 Targa 4S	3	6	Man-7	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.0C91	small car	5	19	28	22	5	No	396
PORSCHE 911 Turbo	3.8	6	AMS-7	4WD	Gasoline	CA	L2LEV160	California LEV-II LEV160	HPRXV03.8T91	small car	5	19	24	21	4	No	428
PORSCHE 911 Turbo	3.8	6	AMS-7	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.8T91	small car	5	19	24	21	4	No	428
PORSCHE 911 Turbo Cabriolet	3.8	6	AMS-7	4WD	Gasoline	CA	L2LEV160	California LEV-II LEV160	HPRXV03.8T91	small car	5	19	24	21	4	No	430
PORSCHE 911 Turbo Cabriolet	3.8	6	AMS-7	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.8T91	small car	5	19	24	21	4	No	430
PORSCHE 911 Turbo S	3.8	6	AMS-7	4WD	Gasoline	CA	L2LEV160	California LEV-II LEV160	HPRXV03.8T91	small car	5	19	24	21	4	No	428
PORSCHE 911 Turbo S	3.8	6	AMS-7	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.8T91	small car	5	19	24	21	4	No	428
PORSCHE 911 Turbo S Cabriolet	3.8	6	AMS-7	4WD	Gasoline	CA	L2LEV160	California LEV-II LEV160	HPRXV03.8T91	small car	5	19	24	21	4	No	430
PORSCHE 911 Turbo S Cabriolet	3.8	6	AMS-7	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXV03.8T91	small car	5	19	24	21	4	No	430
PORSCHE Boxster	2	4	AMS-7	2WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HPRXV02.5B82	small car	6	22	29	25	5	No	353
PORSCHE Boxster	2	4	AMS-7	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HPRXV02.5B82	small car	6	22	29	25	5	No	353
PORSCHE Boxster	2	4	Man-6	2WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HPRXV02.5B82	small car	6	21	28	24	5	No	369
PORSCHE Boxster	2	4	Man-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HPRXV02.5B82	small car	6	21	28	24	5	No	369
PORSCHE Boxster S	2.5	4	AMS-7	2WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HPRXV02.5B82	small car	6	21	28	24	5	No	372
PORSCHE Boxster S	2.5	4	AMS-7	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HPRXV02.5B82	small car	6	21	28	24	5	No	372
PORSCHE Boxster S	2.5	4	Man-6	2WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HPRXV02.5B82	small car	6	20	26	22	5	No	401
PORSCHE Boxster S	2.5	4	Man-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HPRXV02.5B82	small car	6	20	26	22	5	No	401
PORSCHE Cayenne	3.6	6	SemiAuto-8	4WD	Gasoline	FA	B5	Federal Tier 2 Bin 5	HPRXT03.6PV6	standard SUV	5	18	24	20	4	No	432
PORSCHE Cayenne	3.6	6	SemiAuto-8	4WD	Gasoline	CA	U2	California LEV-II ULEV	HPRXT03.6PV6	standard SUV	6	18	24	20	4	No	432
PORSCHE Cayenne GTS	3.6	6	SemiAuto-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HPRXT03.6MCS	standard SUV	6	16	23	19	4	No	476
PORSCHE Cayenne GTS	3.6	6	SemiAuto-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HPRXT03.6MCS	standard SUV	5	16	23	19	4	No	476
PORSCHE Cayenne Platinum	3.6	6	SemiAuto-8	4WD	Gasoline	FA	B5	Federal Tier 2 Bin 5	HPRXT03.6PV6	standard SUV	5	17	23	19	4	No	453
PORSCHE Cayenne Platinum	3.6	6	SemiAuto-8	4WD	Gasoline	CA	U2	California LEV-II ULEV	HPRXT03.6PV6	standard SUV	6	17	23	19	4	No	453
PORSCHE Cayenne S	3.6	6	SemiAuto-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HPRXT03.6MCS	standard SUV	6	17	24	20	4	No	452
PORSCHE Cayenne S	3.6	6	SemiAuto-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HPRXT03.6MCS	standard SUV	5	17	24	20	4	No	452

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PORSCHE Cayenne S e-Hybrid	3	6	AutoMan-8	4WD	Gasoline/Electricity	FA	B5	Federal Tier 2 Bin 5	HPRXT03.0PHV	standard SUV	5	21/47	24/45	22/46	8	Yes	258
PORSCHE Cayenne S e-Hybrid	3	6	AutoMan-8	4WD	Gasoline/Electricity	CA	U2	California LEV-II ULEV	HPRXT03.0PHV	standard SUV	6	21/47	24/45	22/46	8	Yes	258
PORSCHE Cayenne Turbo	4.8	8	SemiAuto-8	4WD	Gasoline	FA	B5	Federal Tier 2 Bin 5	HPRXT04.8CTD	standard SUV	5	14	21	17	3	No	536
PORSCHE Cayenne Turbo	4.8	8	SemiAuto-8	4WD	Gasoline	CA	L2	California LEV-II LEV	HPRXT04.8CTD	standard SUV	5	14	21	17	3	No	536
PORSCHE Cayenne Turbo S	4.8	8	SemiAuto-8	4WD	Gasoline	FA	B5	Federal Tier 2 Bin 5	HPRXT04.8CTD	standard SUV	5	14	21	17	3	No	536
PORSCHE Cayenne Turbo S	4.8	8	SemiAuto-8	4WD	Gasoline	CA	L2	California LEV-II LEV	HPRXT04.8CTD	standard SUV	5	14	21	17	3	No	536
PORSCHE Macan	2	4	AMS-7	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HPRXT02.0MR4	small SUV	6	20	25	22	5	No	399
PORSCHE Macan	2	4	AMS-7	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HPRXT02.0MR4	small SUV	5	20	25	22	5	No	399
PORSCHE Macan GTS	3	6	AMS-7	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HPRXT03.6MCS	small SUV	6	17	23	19	4	No	461
PORSCHE Macan GTS	3	6	AMS-7	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HPRXT03.6MCS	small SUV	5	17	23	19	4	No	461
PORSCHE Macan S	3	6	AMS-7	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HPRXT03.6MCS	small SUV	6	17	23	19	4	No	459
PORSCHE Macan S	3	6	AMS-7	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HPRXT03.6MCS	small SUV	5	17	23	19	4	No	459
PORSCHE Macan Turbo	3.6	6	AMS-7	4WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXT03.6MT6	small SUV	5	17	23	19	4	No	467
PORSCHE Macan Turbo	3.6	6	AMS-7	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXT03.6MT6	small SUV	5	17	23	19	4	No	467
PORSCHE Macan Turbo Kit	3.6	6	AMS-7	4WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HPRXT03.6MT6	small SUV	5	17	23	19	4	No	460
PORSCHE Macan Turbo Kit	3.6	6	AMS-7	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HPRXT03.6MT6	small SUV	5	17	23	19	4	No	460
RAM 1500	3.6	6	Auto-8	2WD	Ethanol/Gas	CA	B4	Federal Tier 2 Bin 4	HCRXT03.65PB	pickup	6	12/17	17/25	14/20	4	No	455/450
RAM 1500	3.6	6	Auto-8	2WD	Ethanol/Gas	FA	B4	Federal Tier 2 Bin 4	HCRXT03.65PB	pickup	6	12/17	17/25	14/20	4	No	455/450
RAM 1500	3.6	6	Auto-8	4WD	Ethanol/Gas	CA	B4	Federal Tier 2 Bin 4	HCRXT03.65PB	pickup	6	11/16	16/23	13/19	4	No	482/475
RAM 1500	3.6	6	Auto-8	4WD	Ethanol/Gas	FA	B4	Federal Tier 2 Bin 4	HCRXT03.65PB	pickup	6	11/16	16/23	13/19	4	No	482/475
RAM 1500	5.7	8	Auto-6	4WD	Gasoline	CA	T3B110	Federal Tier 3 Transitional Bin 110	HCRXT05.75P1	pickup	6	13	19	15	2	No	580
RAM 1500	5.7	8	Auto-6	4WD	Gasoline	FA	T3B110	Federal Tier 3 Transitional Bin 110	HCRXT05.75P1	pickup	6	13	19	15	2	No	580
RAM 1500	5.7	8	Auto-8	2WD	Gasoline	CA	T3B110	Federal Tier 3 Transitional Bin 110	HCRXT05.75P1	pickup	6	15	22	17	3	No	512
RAM 1500	5.7	8	Auto-8	2WD	Gasoline	FA	T3B110	Federal Tier 3 Transitional Bin 110	HCRXT05.75P1	pickup	6	15	22	17	3	No	512

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RAM 1500	5.7	8	Auto-8	4WD	Gasoline	CA	T3B110	Federal Tier 3 Transitional Bin 110	HCRXT05.75P1	pickup	6	15	21	17	3	No	527
RAM 1500	5.7	8	Auto-8	4WD	Gasoline	FA	T3B110	Federal Tier 3 Transitional Bin 110	HCRXT05.75P1	pickup	6	15	21	17	3	No	527
RAM Promaster City	2.4	4	Auto-9	2WD	Gasoline	FA	T3B110	Federal Tier 3 Transitional Bin 110	HCRXT02.45P0	special purpose	6	21	28	24	5	No	374
RAM Promaster City	2.4	4	Auto-9	2WD	Gasoline	CA	U2	California LEV-II ULEV	HCRXT02.45P0	special purpose	6	21	28	24	5	No	374
ROLLS-ROYCE Dawn	6.6	12	SemiAuto-8	2WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HRRGV06.6N74	small car	6	12	19	14	1	No	627
ROLLS-ROYCE Dawn	6.6	12	SemiAuto-8	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HRRGV06.6N74	small car	6	12	19	14	1	No	627
ROLLS-ROYCE Ghost	6.6	12	SemiAuto-8	2WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HRRGV06.6N74	large car	6	12	19	14	1	No	627
ROLLS-ROYCE Ghost	6.6	12	SemiAuto-8	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HRRGV06.6N74	large car	6	12	19	14	1	No	627
ROLLS-ROYCE Ghost EWB	6.6	12	SemiAuto-8	2WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HRRGV06.6N74	large car	6	12	19	14	1	No	627
ROLLS-ROYCE Ghost EWB	6.6	12	SemiAuto-8	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HRRGV06.6N74	large car	6	12	19	14	1	No	627
ROLLS-ROYCE Phantom	6.7	12	SemiAuto-8	2WD	Gasoline	CA	L2	California LEV-II LEV	HRRGV06.7LE2	large car	5	11	19	14	1	No	638
ROLLS-ROYCE Phantom	6.7	12	SemiAuto-8	2WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HRRGV06.7LE2	large car	5	11	19	14	1	No	638
ROLLS-ROYCE Phantom Coupe	6.7	12	SemiAuto-8	2WD	Gasoline	CA	L2	California LEV-II LEV	HRRGV06.7LE2	small car	5	11	19	14	1	No	638
ROLLS-ROYCE Phantom Coupe	6.7	12	SemiAuto-8	2WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HRRGV06.7LE2	small car	5	11	19	14	1	No	638
ROLLS-ROYCE Phantom Drophead Coupe	6.7	12	SemiAuto-8	2WD	Gasoline	CA	L2	California LEV-II LEV	HRRGV06.7LE2	small car	5	11	19	14	1	No	637
ROLLS-ROYCE Phantom Drophead Coupe	6.7	12	SemiAuto-8	2WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HRRGV06.7LE2	small car	5	11	19	14	1	No	637
ROLLS-ROYCE Phantom EWB	6.7	12	SemiAuto-8	2WD	Gasoline	CA	L2	California LEV-II LEV	HRRGV06.7LE2	large car	5	11	19	14	1	No	637
ROLLS-ROYCE Phantom EWB	6.7	12	SemiAuto-8	2WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HRRGV06.7LE2	large car	5	11	19	14	1	No	637
ROLLS-ROYCE Wraith	6.6	12	SemiAuto-8	2WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HRRGV06.6N74	midsize car	6	12	19	15	2	No	604
ROLLS-ROYCE Wraith	6.6	12	SemiAuto-8	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HRRGV06.6N74	midsize car	6	12	19	15	2	No	604
ROUSH Stage 3 Mustang	5	8	Man-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HRIIV05.0VKM	small car	6	13	23	16	2	No	559
ROUSH Stage 3 Mustang	5	8	SemiAuto-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HRIIV05.0VKM	small car	6	14	22	17	3	No	531
SMART ForTwo Convertible	.9	3	AutoMan-6	2WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HMBXV00.9U2A	small car	7	33	38	35	8	Yes	251

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SMART ForTwo Convertible	.9	3	AutoMan-6	2WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HMBXV00.9U2A	small car	7	33	38	35	8	Yes	251
SMART ForTwo Convertible	.9	3	Man-5	2WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HMBXV00.9U2A	small car	7	31	38	34	8	Yes	258
SMART ForTwo Convertible	.9	3	Man-5	2WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HMBXV00.9U2A	small car	7	31	38	34	8	Yes	258
SMART ForTwo Coupe	.9	3	AutoMan-6	2WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HMBXV00.9U2A	small car	7	33	39	35	8	Yes	248
SMART ForTwo Coupe	.9	3	AutoMan-6	2WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HMBXV00.9U2A	small car	7	33	39	35	8	Yes	248
SMART ForTwo Coupe	.9	3	Man-5	2WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HMBXV00.9U2A	small car	7	31	39	34	8	Yes	257
SMART ForTwo Coupe	.9	3	Man-5	2WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HMBXV00.9U2A	small car	7	31	39	34	8	Yes	257
SUBARU BRZ	2	4	Man-6	2WD	Gasoline	CA	L2	California LEV-II LEV	HFJXV02.0AJM	small car	5	21	29	24	5	No	367
SUBARU BRZ	2	4	Man-6	2WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HFJXV02.0AJM	small car	5	21	29	24	5	No	367
SUBARU BRZ	2	4	SemiAuto-6	2WD	Gasoline	CA	L2	California LEV-II LEV	HFJXV02.0AJM	small car	5	24	33	27	6	No	322
SUBARU BRZ	2	4	SemiAuto-6	2WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HFJXV02.0AJM	small car	5	24	33	27	6	No	322
SUBARU Crosstrek	2	4	Man-5	4WD	Gasoline	CA	L2SULEV30/PZEV	California LEV-II SULEV30/PZEV	HFJXT02.0NKR	small SUV	9	23	30	26	6	No	348
SUBARU Crosstrek	2	4	Man-5	4WD	Gasoline	FA	T3B85	Federal Tier 3 Transitional Bin 85	HFJXT02.0NKR	small SUV	7	23	30	26	6	No	348
SUBARU Crosstrek	2	4	SCV-6	4WD	Gasoline	CA	L2SULEV30/PZEV	California LEV-II SULEV30/PZEV	HFJXT02.0NKR	small SUV	9	26	33	29	7	Yes	311
SUBARU Crosstrek	2	4	SCV-6	4WD	Gasoline	FA	T3B85	Federal Tier 3 Transitional Bin 85	HFJXT02.0NKR	small SUV	7	26	33	29	7	Yes	311
SUBARU Forester	2	4	SCV-8	4WD	Gasoline	CA	L2	California LEV-II LEV	HFJXJ02.0FPT	small SUV	5	23	27	25	5	No	359
SUBARU Forester	2	4	SCV-8	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HFJXJ02.0FPT	small SUV	5	23	27	25	5	No	359
SUBARU Forester	2.5	4	CVT	4WD	Gasoline	CA	L3SULEV30/PZEV	California LEV-III SULEV30/PZEV	HFJXJ02.5HRV	small SUV	9	26	32	28	6	No	315
SUBARU Forester	2.5	4	CVT	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HFJXJ02.5HRV	small SUV	7	26	32	28	6	No	315
SUBARU Forester	2.5	4	Man-6	4WD	Gasoline	CA	L3SULEV30/PZEV	California LEV-III SULEV30/PZEV	HFJXJ02.5HRV	small SUV	9	22	28	24	5	No	368
SUBARU Forester	2.5	4	Man-6	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HFJXJ02.5HRV	small SUV	7	22	28	24	5	No	368
SUBARU Impreza	2	4	Man-5	4WD	Gasoline	CA	L3SULEV30/PZEV	California LEV-III SULEV30/PZEV	HFJXV02.0BUY	midsize car	9	24	32	27	6	No	331
SUBARU Impreza	2	4	Man-5	4WD	Gasoline	CA	L3SULEV30/PZEV	California LEV-III SULEV30/PZEV	HFJXV02.0BUY	station wagon	9	24	31	26	6	No	335
SUBARU Impreza	2	4	Man-5	4WD	Gasoline	FA	T3B50	Federal Tier 3 Bin 50	HFJXV02.0BUY	midsize car	7	24	32	27	6	No	331
SUBARU Impreza	2	4	Man-5	4WD	Gasoline	FA	T3B50	Federal Tier 3 Bin 50	HFJXV02.0BUY	station wagon	7	24	31	26	6	No	335
SUBARU Impreza	2	4	SCV-7	4WD	Gasoline	CA	L3SULEV30/PZEV	California LEV-III SULEV30/PZEV	HFJXV02.0BUY	midsize car	9	28	38	32	7	Yes	282
SUBARU Impreza	2	4	SCV-7	4WD	Gasoline	CA	L3SULEV30/PZEV	California LEV-III SULEV30/PZEV	HFJXV02.0BUY	station wagon	9	28	37	31	7	Yes	282
SUBARU Impreza	2	4	SCV-7	4WD	Gasoline	FA	T3B50	Federal Tier 3 Bin 50	HFJXV02.0BUY	midsize car	7	28	38	32	7	Yes	282

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SUBARU Impreza	2	4	SCV-7	4WD	Gasoline	FA	T3B50	Federal Tier 3 Bin 50	HFJXV02.0BUY	station wagon	7	28	37	31	7	Yes	282
SUBARU Impreza Sport	2	4	Man-5	4WD	Gasoline	CA	L3SULEV30/PZEV	California LEV-III SULEV30/PZEV	HFJXV02.0BUY	midsize car	9	23	31	26	6	No	337
SUBARU Impreza Sport	2	4	Man-5	4WD	Gasoline	CA	L3SULEV30/PZEV	California LEV-III SULEV30/PZEV	HFJXV02.0BUY	station wagon	9	22	30	25	5	No	351
SUBARU Impreza Sport	2	4	Man-5	4WD	Gasoline	FA	T3B50	Federal Tier 3 Bin 50	HFJXV02.0BUY	midsize car	7	23	31	26	6	No	337
SUBARU Impreza Sport	2	4	Man-5	4WD	Gasoline	FA	T3B50	Federal Tier 3 Bin 50	HFJXV02.0BUY	station wagon	7	22	30	25	5	No	351
SUBARU Impreza Sport	2	4	SCV-7	4WD	Gasoline	CA	L3SULEV30/PZEV	California LEV-III SULEV30/PZEV	HFJXV02.0BUY	midsize car	9	27	36	30	7	Yes	291
SUBARU Impreza Sport	2	4	SCV-7	4WD	Gasoline	CA	L3SULEV30/PZEV	California LEV-III SULEV30/PZEV	HFJXV02.0BUY	station wagon	9	27	35	30	7	Yes	292
SUBARU Impreza Sport	2	4	SCV-7	4WD	Gasoline	FA	T3B50	Federal Tier 3 Bin 50	HFJXV02.0BUY	midsize car	7	27	36	30	7	Yes	291
SUBARU Impreza Sport	2	4	SCV-7	4WD	Gasoline	FA	T3B50	Federal Tier 3 Bin 50	HFJXV02.0BUY	station wagon	7	27	35	30	7	Yes	292
SUBARU Legacy	2.5	4	SCV-6	4WD	Gasoline	CA	L3SULEV30/PZEV	California LEV-III SULEV30/PZEV	HFJXJ02.5HRV	midsize car	9	25	34	29	7	Yes	311
SUBARU Legacy	2.5	4	SCV-6	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HFJXJ02.5HRV	midsize car	7	25	34	29	7	Yes	311
SUBARU Legacy	2.5	4	SCV-6	4WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HFJXJ02.5JSW	midsize car	5	25	34	29	7	Yes	311
SUBARU Legacy	2.5	4	SCV-6	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HFJXJ02.5JSW	midsize car	5	25	34	29	7	Yes	311
SUBARU Legacy	3.6	6	SCV-6	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HFJXJ03.6KTX	midsize car	6	20	28	23	5	No	387
SUBARU Legacy	3.6	6	SCV-6	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HFJXJ03.6KTX	midsize car	6	20	28	23	5	No	387
SUBARU Outback	2.5	4	SCV-6	4WD	Gasoline	CA	L3SULEV30/PZEV	California LEV-III SULEV30/PZEV	HFJXJ02.5HRV	small SUV	9	25	32	28	6	No	319
SUBARU Outback	2.5	4	SCV-6	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HFJXJ02.5HRV	small SUV	7	25	32	28	6	No	319
SUBARU Outback	2.5	4	SCV-6	4WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HFJXJ02.5JSW	small SUV	5	25	32	28	6	No	319
SUBARU Outback	2.5	4	SCV-6	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HFJXJ02.5JSW	small SUV	5	25	32	28	6	No	319
SUBARU Outback	3.6	6	SCV-6	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HFJXJ03.6KTX	small SUV	6	20	27	22	5	No	398
SUBARU Outback	3.6	6	SCV-6	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HFJXJ03.6KTX	small SUV	6	20	27	22	5	No	398
SUBARU WRX	2	4	Man-6	4WD	Gasoline	CA	L2	California LEV-II LEV	HFJXJ02.0FPT	small car	5	20	27	23	5	No	385
SUBARU WRX	2	4	Man-6	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HFJXJ02.0FPT	small car	5	20	27	23	5	No	385
SUBARU WRX	2	4	SCV-8	4WD	Gasoline	CA	L2	California LEV-II LEV	HFJXJ02.0FPT	small car	5	18	24	21	4	No	420
SUBARU WRX	2	4	SCV-8	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HFJXJ02.0FPT	small car	5	18	24	21	4	No	420
SUBARU WRX	2.5	4	Man-6	4WD	Gasoline	CA	L2	California LEV-II LEV	HFJXV02.5PHU	small car	5	17	23	19	4	No	458
SUBARU WRX	2.5	4	Man-6	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HFJXV02.5PHU	small car	5	17	23	19	4	No	458
TESLA Model S 60D	N/A	N/A	Auto-1	4WD	Electricity	FA	T3B0	Federal Tier 3 Bin 0	HTSLV00.0L2S	large car	10	101	107	104	10	Elite	0
TESLA Model S 60kWh	N/A	N/A	Auto-1	2WD	Electricity	FA	T3B0	Federal Tier 3 Bin 0	HTSLV00.0L1S	large car	10	98	101	99	10	Elite	0
TESLA Model S 75D	N/A	N/A	Auto-1	4WD	Electricity	FA	T3B0	Federal Tier 3 Bin 0	HTSLV00.0L2S	large car	10	102	105	103	10	Elite	0

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Model	Displ	Cyl	Trans	Drive	Fuel	Cert Region	Stnd	Stnd Description	Underhood ID	Veh Class	Air Pollution Score	City MPG	Hwy MPG	Cmb MPG	Greenhouse Gas Score	SmartWay	Comb CO2
TESLA Model S 75kWh	N/A	N/A	Auto-1	2WD	Electricity	FA	T3B0	Federal Tier 3 Bin 0	HTSLV00.0L1S	large car	10	97	100	98	10	Elite	0
TESLA Model S P100D	N/A	N/A	Auto-1	4WD	Electricity	FA	T3B0	Federal Tier 3 Bin 0	HTSLV00.0L2S	large car	10	92	105	98	10	Elite	0
TESLA Model S P90D	N/A	N/A	Auto-1	4WD	Electricity	FA	T3B0	Federal Tier 3 Bin 0	HTSLV00.0L2S	large car	10	92	100	95	10	Elite	0
TESLA Model X 60D	N/A	N/A	Auto-1	4WD	Electricity	FA	T3B0	Federal Tier 3 Bin 0	HTSLV00.0L2X	standard SUV	10	91	94	93	10	Elite	0
TESLA Model X 75D	N/A	N/A	Auto-1	4WD	Electricity	FA	T3B0	Federal Tier 3 Bin 0	HTSLV00.0L2X	standard SUV	10	91	95	93	10	Elite	0
TESLA Model X 90D	N/A	N/A	Auto-1	4WD	Electricity	FA	T3B0	Federal Tier 3 Bin 0	HTSLV00.0L2X	standard SUV	10	90	94	92	10	Elite	0
TESLA Model X P100D	N/A	N/A	Auto-1	4WD	Electricity	FA	T3B0	Federal Tier 3 Bin 0	HTSLV00.0L2X	standard SUV	10	81	92	86	10	Elite	0
TESLA Model X P90D	N/A	N/A	Auto-1	4WD	Electricity	FA	T3B0	Federal Tier 3 Bin 0	HTSLV00.0L2X	standard SUV	10	89	90	89	10	Elite	0
TOYOTA 4Runner	4	6	SemiAuto-5	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HTYXT04.0B6S	standard SUV	6	17	21	18	3	No	479
TOYOTA 4Runner	4	6	SemiAuto-5	2WD	Gasoline	CA	U2	California LEV-II ULEV	HTYXT04.0B6S	standard SUV	6	17	21	18	3	No	479
TOYOTA 4Runner	4	6	SemiAuto-5	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HTYXT04.0B6S	standard SUV	6	17	20	18	3	No	491
TOYOTA 4Runner	4	6	SemiAuto-5	4WD	Gasoline	CA	U2	California LEV-II ULEV	HTYXT04.0B6S	standard SUV	6	17	20	18	3	No	491
TOYOTA 86	2	4	Man-6	2WD	Gasoline	CA	L2	California LEV-II LEV	HFJXV02.0AJM	small car	5	21	28	24	5	No	373
TOYOTA 86	2	4	Man-6	2WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HFJXV02.0AJM	small car	5	21	28	24	5	No	373
TOYOTA 86	2	4	SemiAuto-6	2WD	Gasoline	CA	L2	California LEV-II LEV	HFJXV02.0AJM	small car	5	24	32	27	6	No	328
TOYOTA 86	2	4	SemiAuto-6	2WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HFJXV02.0AJM	small car	5	24	32	27	6	No	328
TOYOTA Avalon	3.5	6	SemiAuto-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HTYXV03.5B6C	midsize car	6	21	30	24	5	No	365
TOYOTA Avalon	3.5	6	SemiAuto-6	2WD	Gasoline	CA	U2	California LEV-II ULEV	HTYXV03.5B6C	midsize car	6	21	30	24	5	No	365
TOYOTA Avalon Hybrid	2.5	4	SCV-6	2WD	Gasoline	CA	L3SULEV30/PZEV	California LEV-III SULEV30/PZEV	HTYXV02.5P34	midsize car	9	40	39	40	9	Yes	223
TOYOTA Avalon Hybrid	2.5	4	SCV-6	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HTYXV02.5P34	midsize car	8	40	39	40	9	Yes	223
TOYOTA Camry	2.5	4	SemiAuto-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HTYXJ02.5B6L	midsize car	6	24	33	27	6	No	321
TOYOTA Camry	2.5	4	SemiAuto-6	2WD	Gasoline	CA	U2	California LEV-II ULEV	HTYXJ02.5B6L	midsize car	6	24	33	27	6	No	321
TOYOTA Camry	2.5	4	SemiAuto-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HTYXV02.5B6D	midsize car	6	24	33	27	6	No	321
TOYOTA Camry	2.5	4	SemiAuto-6	2WD	Gasoline	CA	U2	California LEV-II ULEV	HTYXV02.5B6D	midsize car	6	24	33	27	6	No	321
TOYOTA Camry	3.5	6	SemiAuto-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HTYXV03.5B6C	midsize car	6	21	30	24	5	No	363
TOYOTA Camry	3.5	6	SemiAuto-6	2WD	Gasoline	CA	U2	California LEV-II ULEV	HTYXV03.5B6C	midsize car	6	21	30	24	5	No	363
TOYOTA Camry Hybrid LE	2.5	4	CVT	2WD	Gasoline	CA	L3SULEV30/PZEV	California LEV-III SULEV30/PZEV	HTYXV02.5P34	midsize car	9	42	38	40	9	Yes	221
TOYOTA Camry Hybrid LE	2.5	4	CVT	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HTYXV02.5P34	midsize car	8	42	38	40	9	Yes	221
TOYOTA Camry Hybrid XLE/SE	2.5	4	CVT	2WD	Gasoline	CA	L3SULEV30/PZEV	California LEV-III SULEV30/PZEV	HTYXV02.5P34	midsize car	9	40	37	38	9	Yes	230
TOYOTA Camry Hybrid XLE/SE	2.5	4	CVT	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HTYXV02.5P34	midsize car	8	40	37	38	9	Yes	230

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Model	Displ	Cyl	Trans	Drive	Fuel	Cert Region	Stnd	Stnd Description	Underhood ID	Veh Class	Air Pollution Score	City MPG	Hwy MPG	Cmb MPG	Greenhouse Gas Score	SmartWay	Comb CO2
TOYOTA Corolla	1.8	4	CVT	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HTYXV01.8B6A	midsize car	6	28	36	32	7	Yes	281
TOYOTA Corolla	1.8	4	CVT	2WD	Gasoline	CA	U2	California LEV-II ULEV	HTYXV01.8B6A	midsize car	6	28	36	32	7	Yes	281
TOYOTA Corolla	1.8	4	Man-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HTYXV01.8B6A	midsize car	6	27	35	30	7	Yes	289
TOYOTA Corolla	1.8	4	Man-6	2WD	Gasoline	CA	U2	California LEV-II ULEV	HTYXV01.8B6A	midsize car	6	27	35	30	7	Yes	289
TOYOTA Corolla	1.8	4	SCV-7	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HTYXV01.8B6A	midsize car	6	28	35	31	7	Yes	286
TOYOTA Corolla	1.8	4	SCV-7	2WD	Gasoline	CA	U2	California LEV-II ULEV	HTYXV01.8B6A	midsize car	6	28	35	31	7	Yes	286
TOYOTA Corolla LE Eco	1.8	4	CVT	2WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HTYXV01.8M5B	midsize car	7	29	38	33	8	Yes	271
TOYOTA Corolla LE Eco	1.8	4	CVT	2WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HTYXV01.8M5B	midsize car	7	30	40	34	8	Yes	263
TOYOTA Corolla LE Eco	1.8	4	CVT	2WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HTYXV01.8M5B	midsize car	7	29	38	33	8	Yes	271
TOYOTA Corolla LE Eco	1.8	4	CVT	2WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HTYXV01.8M5B	midsize car	7	30	40	34	8	Yes	263
TOYOTA Corolla iM	1.8	4	Man-6	2WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HTYXV01.8M5B	midsize car	7	27	35	30	7	Yes	297
TOYOTA Corolla iM	1.8	4	Man-6	2WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HTYXV01.8M5B	midsize car	7	27	35	30	7	Yes	297
TOYOTA Corolla iM	1.8	4	SCV-7	2WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HTYXV01.8M5B	midsize car	7	28	36	31	7	Yes	283
TOYOTA Corolla iM	1.8	4	SCV-7	2WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HTYXV01.8M5B	midsize car	7	28	36	31	7	Yes	283
TOYOTA Highlander	2.7	4	SemiAuto-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HTYXT02.7B6N	small SUV	6	20	24	22	5	No	407
TOYOTA Highlander	2.7	4	SemiAuto-6	2WD	Gasoline	CA	U2	California LEV-II ULEV	HTYXT02.7B6N	small SUV	6	20	24	22	5	No	407
TOYOTA Highlander	3.5	6	SemiAuto-8	2WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HTYXT03.5M5M	small SUV	7	20	27	23	5	No	391
TOYOTA Highlander	3.5	6	SemiAuto-8	2WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HTYXT03.5M5M	small SUV	7	20	27	23	5	No	391
TOYOTA Highlander	3.5	6	SemiAuto-8	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HTYXT03.5M5M	standard SUV	7	19	26	22	5	No	405
TOYOTA Highlander	3.5	6	SemiAuto-8	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HTYXT03.5M5M	standard SUV	7	20	26	22	5	No	398
TOYOTA Highlander	3.5	6	SemiAuto-8	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HTYXT03.5M5M	standard SUV	7	19	26	22	5	No	405
TOYOTA Highlander	3.5	6	SemiAuto-8	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HTYXT03.5M5M	standard SUV	7	20	26	22	5	No	398
TOYOTA Highlander AWD LE	3.5	6	SemiAuto-8	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HTYXT03.5M5M	standard SUV	7	20	27	23	5	No	390
TOYOTA Highlander AWD LE	3.5	6	SemiAuto-8	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HTYXT03.5M5M	standard SUV	7	20	27	23	5	No	390
TOYOTA Highlander Hybrid	3.5	6	SCV-6	4WD	Gasoline	CA	L3SULEV30	California LEV-III SULEV30	HTYXT03.5P3S	standard SUV	8	29	27	28	6	No	311
TOYOTA Highlander Hybrid	3.5	6	SCV-6	4WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HTYXT03.5P3S	standard SUV	8	29	27	28	6	No	311
TOYOTA Highlander Hybrid LE Plus	3.5	6	SCV-6	4WD	Gasoline	CA	L3SULEV30	California LEV-III SULEV30	HTYXT03.5P3S	standard SUV	8	30	28	29	7	Yes	305
TOYOTA Highlander Hybrid LE Plus	3.5	6	SCV-6	4WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HTYXT03.5P3S	standard SUV	8	30	28	29	7	Yes	305

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Model	Displ	Cyl	Trans	Drive	Fuel	Cert Region	Stnd	Stnd Description	Underhood ID	Veh Class	Air Pollution Score	City MPG	Hwy MPG	Cmb MPG	Greenhouse Gas Score	SmartWay	Comb CO2
TOYOTA Highlander LE/XLE/SE/LTD	3.5	6	SemiAuto-8	2WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HTYXT03.5M5M	small SUV	7	21	27	23	5	No	384
TOYOTA Highlander LE/XLE/SE/LTD	3.5	6	SemiAuto-8	2WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HTYXT03.5M5M	small SUV	7	21	27	23	5	No	384
TOYOTA Land Cruiser	5.7	8	SemiAuto-8	4WD	Gasoline	FA	B5	Federal Tier 2 Bin 5	HTYXT05.7BEY	standard SUV	5	13	18	15	2	No	595
TOYOTA Land Cruiser	5.7	8	SemiAuto-8	4WD	Gasoline	CA	U2	California LEV-II ULEV	HTYXT05.7BEY	standard SUV	6	13	18	15	2	No	595
TOYOTA Mirai	N/A	N/A	CVT	2WD	Hydrogen	FA	T3B0	Federal Tier 3 Bin 0	HTYXV00.0DA7	small car	10	67	67	67	10	Elite	0
TOYOTA Mirai	N/A	N/A	CVT	2WD	Hydrogen	CA	ZEV	California ZEV	HTYXV00.0DA7	small car	10	67	67	67	10	Elite	0
TOYOTA Prius	1.8	4	CVT	2WD	Gasoline	CA	L3SULEV30/PZEV	California LEV-III SULEV30/PZEV	HTYXV01.8P33	midsize car	9	54	50	52	10	Elite	171
TOYOTA Prius	1.8	4	CVT	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HTYXV01.8P33	midsize car	8	54	50	52	10	Yes	171
TOYOTA Prius	1.8	4	CVT	2WD	Gasoline	CA	L3SULEV30/PZEV	California LEV-III SULEV30/PZEV	HTYXV01.8P34	midsize car	9	54	50	52	10	Elite	171
TOYOTA Prius	1.8	4	CVT	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HTYXV01.8P34	midsize car	8	54	50	52	10	Yes	171
TOYOTA Prius Eco	1.8	4	CVT	2WD	Gasoline	CA	L3SULEV30/PZEV	California LEV-III SULEV30/PZEV	HTYXV01.8P34	midsize car	9	58	53	56	10	Elite	158
TOYOTA Prius Eco	1.8	4	CVT	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HTYXV01.8P34	midsize car	8	58	53	56	10	Yes	158
TOYOTA Prius Prime	1.8	4	CVT	2WD	Gasoline/Electricity	CA	L3SULEV30/PZEV	California LEV-III SULEV30/PZEV	HTYXV01.8P35	midsize car	9	55/145	53/121	54/133	10	Elite	78
TOYOTA Prius Prime	1.8	4	CVT	2WD	Gasoline/Electricity	FA	T3B30	Federal Tier 3 Bin 30	HTYXV01.8P35	midsize car	8	55/145	53/121	54/133	10	Yes	78
TOYOTA Prius c	1.5	4	CVT	2WD	Gasoline	CA	L3SULEV30	California LEV-III SULEV30	HTYXV01.5P34	small car	8	48	43	46	10	Yes	193
TOYOTA Prius c	1.5	4	CVT	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HTYXV01.5P34	small car	8	48	43	46	10	Yes	193
TOYOTA Prius v	1.8	4	CVT	2WD	Gasoline	CA	L3SULEV30	California LEV-III SULEV30	HTYXV01.8P3U	station wagon	8	43	39	41	9	Yes	217
TOYOTA Prius v	1.8	4	CVT	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HTYXV01.8P3U	station wagon	8	43	39	41	9	Yes	217
TOYOTA RAV4	2.5	4	SemiAuto-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HTYXJ02.5B6L	small SUV	6	23	29	25	5	No	349
TOYOTA RAV4	2.5	4	SemiAuto-6	2WD	Gasoline	CA	U2	California LEV-II ULEV	HTYXJ02.5B6L	small SUV	6	23	29	25	5	No	349
TOYOTA RAV4	2.5	4	SemiAuto-6	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HTYXJ02.5B6L	small SUV	6	22	28	25	5	No	357
TOYOTA RAV4	2.5	4	SemiAuto-6	4WD	Gasoline	CA	U2	California LEV-II ULEV	HTYXJ02.5B6L	small SUV	6	22	28	25	5	No	357
TOYOTA RAV4 Hybrid	2.5	4	SCV-6	4WD	Gasoline	CA	L3SULEV30	California LEV-III SULEV30	HTYXT02.5P3M	small SUV	8	34	30	32	7	Yes	275
TOYOTA RAV4 Hybrid	2.5	4	SCV-6	4WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HTYXT02.5P3M	small SUV	8	34	30	32	7	Yes	275
TOYOTA RAV4 LE/XLE	2.5	4	SemiAuto-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HTYXJ02.5B6L	small SUV	6	23	30	26	6	No	338
TOYOTA RAV4 LE/XLE	2.5	4	SemiAuto-6	2WD	Gasoline	CA	U2	California LEV-II ULEV	HTYXJ02.5B6L	small SUV	6	23	30	26	6	No	338
TOYOTA RAV4 Limited	2.5	4	SemiAuto-6	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HTYXJ02.5B6L	small SUV	6	22	28	24	5	No	363
TOYOTA RAV4 Limited	2.5	4	SemiAuto-6	4WD	Gasoline	CA	U2	California LEV-II ULEV	HTYXJ02.5B6L	small SUV	6	22	28	24	5	No	363
TOYOTA Sequoia	5.7	8	SemiAuto-6	2WD	Gasoline	FA	B5	Federal Tier 2 Bin 5	HTYXT05.7BEY	standard SUV	5	13	17	15	2	No	610
TOYOTA Sequoia	5.7	8	SemiAuto-6	2WD	Gasoline	CA	U2	California LEV-II ULEV	HTYXT05.7BEY	standard SUV	6	13	17	15	2	No	610

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Model	Displ	Cyl	Trans	Drive	Fuel	Cert Region	Stnd	Stnd Description	Underhood ID	Veh Class	Air Pollution Score	City MPG	Hwy MPG	Cmb MPG	Greenhouse Gas Score	SmartWay	Comb CO2
TOYOTA Sequoia	5.7	8	SemiAuto-6	4WD	Gasoline	FA	B5	Federal Tier 2 Bin 5	HTYXT05.7BEY	standard SUV	5	13	17	14	1	No	613
TOYOTA Sequoia	5.7	8	SemiAuto-6	4WD	Gasoline	CA	U2	California LEV-II ULEV	HTYXT05.7BEY	standard SUV	6	13	17	14	1	No	613
TOYOTA Sequoia FFV	5.7	8	SemiAuto-6	4WD	Ethanol/Gas	FA	B5	Federal Tier 2 Bin 5	HTYXT05.7XE8	standard SUV	5	9/13	13/17	10/14	1	No	609/632
TOYOTA Sienna	3.5	6	SemiAuto-8	2WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HTYXT03.5M5M	minivan	7	19	27	22	5	No	409
TOYOTA Sienna	3.5	6	SemiAuto-8	2WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HTYXT03.5M5M	minivan	7	19	27	22	5	No	409
TOYOTA Sienna	3.5	6	SemiAuto-8	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HTYXT03.5M5M	minivan	7	18	24	20	4	No	441
TOYOTA Sienna	3.5	6	SemiAuto-8	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HTYXT03.5M5M	minivan	7	18	24	20	4	No	441
TOYOTA Tacoma	2.7	4	Man-5	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HTYXT02.7M5R	pickup	7	19	21	20	4	No	448
TOYOTA Tacoma	2.7	4	Man-5	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HTYXT02.7M5R	pickup	7	19	21	20	4	No	448
TOYOTA Tacoma	2.7	4	SemiAuto-6	2WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HTYXT02.7M5P	pickup	7	19	23	21	4	No	427
TOYOTA Tacoma	2.7	4	SemiAuto-6	2WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HTYXT02.7M5P	pickup	7	19	23	21	4	No	427
TOYOTA Tacoma	2.7	4	SemiAuto-6	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HTYXT02.7M5P	pickup	7	19	22	20	4	No	441
TOYOTA Tacoma	2.7	4	SemiAuto-6	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HTYXT02.7M5P	pickup	7	19	22	20	4	No	441
TOYOTA Tacoma	3.5	6	Man-6	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HTYXT03.5M5N	pickup	7	17	20	18	3	No	483
TOYOTA Tacoma	3.5	6	Man-6	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HTYXT03.5M5N	pickup	7	17	21	18	3	No	481
TOYOTA Tacoma	3.5	6	Man-6	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HTYXT03.5M5N	pickup	7	17	20	18	3	No	483
TOYOTA Tacoma	3.5	6	Man-6	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HTYXT03.5M5N	pickup	7	17	21	18	3	No	481
TOYOTA Tacoma	3.5	6	SemiAuto-6	2WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HTYXT03.5M5N	pickup	7	19	24	21	4	No	431
TOYOTA Tacoma	3.5	6	SemiAuto-6	2WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HTYXT03.5M5N	pickup	7	19	24	21	4	No	431
TOYOTA Tacoma	3.5	6	SemiAuto-6	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HTYXT03.5M5N	pickup	7	18	23	20	4	No	446
TOYOTA Tacoma	3.5	6	SemiAuto-6	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HTYXT03.5M5N	pickup	7	18	23	20	4	No	446
TOYOTA Tundra	4.6	8	SemiAuto-6	2WD	Gasoline	FA	B5	Federal Tier 2 Bin 5	HTYXT04.6BEW	pickup	5	15	19	16	2	No	554
TOYOTA Tundra	4.6	8	SemiAuto-6	2WD	Gasoline	CA	U2	California LEV-II ULEV	HTYXT04.6BEW	pickup	6	15	19	16	2	No	554
TOYOTA Tundra	4.6	8	SemiAuto-6	4WD	Gasoline	FA	B5	Federal Tier 2 Bin 5	HTYXT04.6BEW	pickup	5	14	18	16	2	No	568
TOYOTA Tundra	4.6	8	SemiAuto-6	4WD	Gasoline	CA	U2	California LEV-II ULEV	HTYXT04.6BEW	pickup	6	14	18	16	2	No	568
TOYOTA Tundra	5.7	8	SemiAuto-6	2WD	Gasoline	FA	B5	Federal Tier 2 Bin 5	HTYXT05.7BEW	pickup	5	13	18	15	2	No	592
TOYOTA Tundra	5.7	8	SemiAuto-6	2WD	Gasoline	CA	U2	California LEV-II ULEV	HTYXT05.7BEW	pickup	6	13	18	15	2	No	592
TOYOTA Tundra	5.7	8	SemiAuto-6	4WD	Gasoline	FA	B5	Federal Tier 2 Bin 5	HTYXT05.7BEW	pickup	5	13	17	15	2	No	606
TOYOTA Tundra	5.7	8	SemiAuto-6	4WD	Gasoline	CA	U2	California LEV-II ULEV	HTYXT05.7BEW	pickup	6	13	17	15	2	No	606
TOYOTA Tundra FFV	5.7	8	SemiAuto-6	2WD	Ethanol/Gas	FA	B5	Federal Tier 2 Bin 5	HTYXT05.7XE8	pickup	5	9/13	13/18	11/15	2	No	575/594
TOYOTA Tundra FFV	5.7	8	SemiAuto-6	4WD	Ethanol/Gas	FA	B5	Federal Tier 2 Bin 5	HTYXT05.7XE8	pickup	5	9/13	12/17	10/15	2	No	600/604

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(Limited to releasable data submitted earlier than 02/15/2017)

Model	Displ	Cyl	Trans	Drive	Fuel	Cert Region	Stnd	Stnd Description	Underhood ID	Veh Class	Air Pollution Score	City MPG	Hwy MPG	Cmb MPG	Greenhouse Gas Score	SmartWay	Comb CO2
TOYOTA Yaris	1.5	4	Auto-4	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HTYXV01.5B6B	small car	6	30	35	32	7	Yes	278
TOYOTA Yaris	1.5	4	Auto-4	2WD	Gasoline	CA	U2	California LEV-II ULEV	HTYXV01.5B6B	small car	6	30	35	32	7	Yes	278
TOYOTA Yaris	1.5	4	Man-5	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HTYXV01.5B6B	small car	6	30	36	33	8	Yes	271
TOYOTA Yaris	1.5	4	Man-5	2WD	Gasoline	CA	U2	California LEV-II ULEV	HTYXV01.5B6B	small car	6	30	36	33	8	Yes	271
TOYOTA Yaris iA	1.5	4	Man-6	2WD	Gasoline	CA	L2ULEV125	California LEV-II ULEV125	HTYXV01.5F6A	small car	6	30	39	34	8	Yes	264
TOYOTA Yaris iA	1.5	4	Man-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HTYXV01.5F6A	small car	6	30	39	34	8	Yes	264
TOYOTA Yaris iA	1.5	4	SemiAuto-6	2WD	Gasoline	CA	L2ULEV125	California LEV-II ULEV125	HTYXV01.5F6A	small car	6	32	40	35	8	Yes	249
TOYOTA Yaris iA	1.5	4	SemiAuto-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HTYXV01.5F6A	small car	6	32	40	35	8	Yes	249
VOLKSWAGEN Beetle	1.8	4	SemiAuto-6	2WD	Gasoline	CA	S2	California LEV-II SULEV	HVGAV02.0VPD	small car	9	24	33	28	6	No	322
VOLKSWAGEN Beetle	1.8	4	SemiAuto-6	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HVGAV02.0VPD	small car	8	24	33	28	6	No	322
VOLKSWAGEN Beetle	2	4	AMS-6	2WD	Gasoline	CA	S2	California LEV-II SULEV	HVGAV02.0VPD	small car	9	23	29	26	6	No	349
VOLKSWAGEN Beetle	2	4	AMS-6	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HVGAV02.0VPD	small car	8	23	29	26	6	No	349
VOLKSWAGEN Beetle Convertible	1.8	4	SemiAuto-6	2WD	Gasoline	CA	S2	California LEV-II SULEV	HVGAV02.0VPD	small car	9	24	33	28	6	No	322
VOLKSWAGEN Beetle Convertible	1.8	4	SemiAuto-6	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HVGAV02.0VPD	small car	8	24	33	28	6	No	322
VOLKSWAGEN Beetle Dune	1.8	4	SemiAuto-6	2WD	Gasoline	CA	S2	California LEV-II SULEV	HVGAV02.0VPD	small car	9	24	31	27	6	No	331
VOLKSWAGEN Beetle Dune	1.8	4	SemiAuto-6	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HVGAV02.0VPD	small car	8	24	31	27	6	No	331
VOLKSWAGEN Beetle Dune Convertible	1.8	4	SemiAuto-6	2WD	Gasoline	CA	S2	California LEV-II SULEV	HVGAV02.0VPD	small car	9	24	31	27	6	No	331
VOLKSWAGEN Beetle Dune Convertible	1.8	4	SemiAuto-6	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HVGAV02.0VPD	small car	8	24	31	27	6	No	331
VOLKSWAGEN CC	2	4	AMS-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HVGAJ02.0VUE	small car	6	22	31	25	5	No	349
VOLKSWAGEN CC	2	4	AMS-6	2WD	Gasoline	CA	U2	California LEV-II ULEV	HVGAJ02.0VUE	small car	6	22	31	25	5	No	349
VOLKSWAGEN CC	2	4	AMS-6	2WD	Gasoline	CA	S2	California LEV-II SULEV	HVGAV02.0VPE	small car	9	22	31	25	5	No	349
VOLKSWAGEN CC	2	4	AMS-6	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HVGAV02.0VPE	small car	8	22	31	25	5	No	349
VOLKSWAGEN CC 4Motion	3.6	6	SemiAuto-6	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HVGAV03.6VUF	small car	6	17	25	20	4	No	446
VOLKSWAGEN CC 4Motion	3.6	6	SemiAuto-6	4WD	Gasoline	CA	U2	California LEV-II ULEV	HVGAV03.6VUF	small car	6	17	25	20	4	No	446
VOLKSWAGEN GTI	2	4	AMS-6	2WD	Gasoline	CA	S2	California LEV-II SULEV	HVGAV02.0APA	small car	9	24	32	27	6	No	325
VOLKSWAGEN GTI	2	4	AMS-6	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HVGAV02.0APA	small car	8	24	32	27	6	No	325
VOLKSWAGEN GTI	2	4	Man-6	2WD	Gasoline	CA	S2	California LEV-II SULEV	HVGAV02.0APA	small car	9	24	34	28	6	No	319
VOLKSWAGEN GTI	2	4	Man-6	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HVGAV02.0APA	small car	8	24	34	28	6	No	319
VOLKSWAGEN Golf	1.8	4	Man-5	2WD	Gasoline	CA	S2	California LEV-II SULEV	HVGAV02.0APA	small car	9	25	36	29	7	Yes	305

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Model	Displ	Cyl	Trans	Drive	Fuel	Cert Region	Stnd	Stnd Description	Underhood ID	Veh Class	Air Pollution Score	City MPG	Hwy MPG	Cmb MPG	Greenhouse Gas Score	SmartWay	Comb CO2
VOLKSWAGEN Golf	1.8	4	Man-5	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HVGAV02.0APA	small car	8	25	36	29	7	Yes	305
VOLKSWAGEN Golf	1.8	4	SemiAuto-6	2WD	Gasoline	CA	S2	California LEV-II SULEV	HVGAV02.0APA	small car	9	25	35	29	7	Yes	309
VOLKSWAGEN Golf	1.8	4	SemiAuto-6	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HVGAV02.0APA	small car	8	25	35	29	7	Yes	309
VOLKSWAGEN Golf Alltrack	1.8	4	AMS-6	4WD	Gasoline	CA	S2	California LEV-II SULEV	HVGAV02.0APA	station wagon	9	22	30	25	5	No	354
VOLKSWAGEN Golf Alltrack	1.8	4	AMS-6	4WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HVGAV02.0APA	station wagon	8	22	30	25	5	No	354
VOLKSWAGEN Golf Alltrack	1.8	4	Man-6	4WD	Gasoline	CA	S2	California LEV-II SULEV	HVGAV02.0APA	station wagon	9	22	32	26	6	No	347
VOLKSWAGEN Golf Alltrack	1.8	4	Man-6	4WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HVGAV02.0APA	station wagon	8	22	32	26	6	No	347
VOLKSWAGEN Golf R	2	4	AMS-6	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HVGAV02.0AUA	small car	6	23	30	25	5	No	347
VOLKSWAGEN Golf R	2	4	AMS-6	4WD	Gasoline	CA	U2	California LEV-II ULEV	HVGAV02.0AUA	small car	6	23	30	25	5	No	347
VOLKSWAGEN Golf R	2	4	Man-6	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HVGAV02.0AUA	small car	6	22	31	25	5	No	354
VOLKSWAGEN Golf R	2	4	Man-6	4WD	Gasoline	CA	U2	California LEV-II ULEV	HVGAV02.0AUA	small car	6	22	31	25	5	No	354
VOLKSWAGEN Golf SportWagen	1.8	4	Man-5	2WD	Gasoline	CA	S2	California LEV-II SULEV	HVGAV02.0APA	station wagon	9	25	35	28	6	No	313
VOLKSWAGEN Golf SportWagen	1.8	4	Man-5	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HVGAV02.0APA	station wagon	8	25	35	28	6	No	313
VOLKSWAGEN Golf SportWagen	1.8	4	SemiAuto-6	2WD	Gasoline	CA	S2	California LEV-II SULEV	HVGAV02.0APA	station wagon	9	25	34	29	7	Yes	309
VOLKSWAGEN Golf SportWagen	1.8	4	SemiAuto-6	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HVGAV02.0APA	station wagon	8	25	34	29	7	Yes	309
VOLKSWAGEN Golf SportWagen 4Motion	1.8	4	AMS-6	4WD	Gasoline	CA	S2	California LEV-II SULEV	HVGAV02.0APA	station wagon	9	22	30	25	5	No	354
VOLKSWAGEN Golf SportWagen 4Motion	1.8	4	AMS-6	4WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HVGAV02.0APA	station wagon	8	22	30	25	5	No	354
VOLKSWAGEN Golf SportWagen 4Motion	1.8	4	Man-6	4WD	Gasoline	CA	S2	California LEV-II SULEV	HVGAV02.0APA	station wagon	9	22	32	26	6	No	347
VOLKSWAGEN Golf SportWagen 4Motion	1.8	4	Man-6	4WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HVGAV02.0APA	station wagon	8	22	32	26	6	No	347
VOLKSWAGEN Jetta	1.4	4	Man-5	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HVGAV01.4VUP	small car	6	28	40	33	8	Yes	271
VOLKSWAGEN Jetta	1.4	4	Man-5	2WD	Gasoline	CA	U2	California LEV-II ULEV	HVGAV01.4VUP	small car	6	28	40	33	8	Yes	271
VOLKSWAGEN Jetta	1.4	4	SemiAuto-6	2WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	HVGAV01.4V7P	small car	7	28	38	32	7	Yes	282
VOLKSWAGEN Jetta	1.4	4	SemiAuto-6	2WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	HVGAV01.4V7P	small car	7	28	38	32	7	Yes	282
VOLKSWAGEN Jetta	1.8	4	SemiAuto-6	2WD	Gasoline	CA	S2	California LEV-II SULEV	HVGAV02.0VPD	small car	9	25	35	29	7	Yes	311
VOLKSWAGEN Jetta	1.8	4	SemiAuto-6	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HVGAV02.0VPD	small car	8	25	35	29	7	Yes	311
VOLKSWAGEN Jetta	2	4	AMS-6	2WD	Gasoline	CA	S2	California LEV-II SULEV	HVGAV02.0VPD	small car	9	24	33	27	6	No	326
VOLKSWAGEN Jetta	2	4	AMS-6	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HVGAV02.0VPD	small car	8	24	33	27	6	No	326
VOLKSWAGEN Jetta	2	4	Man-6	2WD	Gasoline	CA	S2	California LEV-II SULEV	HVGAV02.0VPD	small car	9	23	33	27	6	No	335

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Model	Displ	Cyl	Trans	Drive	Fuel	Cert Region	Stnd	Stnd Description	Underhood ID	Veh Class	Air Pollution Score	City MPG	Hwy MPG	Cmb MPG	Greenhouse Gas Score	SmartWay	Comb CO2
VOLKSWAGEN Jetta	2	4	Man-6	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HVGAV02.0VPD	small car	8	23	33	27	6	No	335
VOLKSWAGEN Passat	1.8	4	SemiAuto-6	2WD	Gasoline	CA	S2	California LEV-II SULEV	HVGAV02.0VPD	midsize car	9	23	34	27	6	No	329
VOLKSWAGEN Passat	1.8	4	SemiAuto-6	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HVGAV02.0VPD	midsize car	8	23	34	27	6	No	329
VOLKSWAGEN Passat	3.6	6	AMS-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HVGAV03.6VUG	midsize car	6	20	28	23	5	No	390
VOLKSWAGEN Passat	3.6	6	AMS-6	2WD	Gasoline	CA	U2	California LEV-II ULEV	HVGAV03.6VUG	midsize car	6	20	28	23	5	No	390
VOLKSWAGEN Tiguan	2	4	SemiAuto-6	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HVGAJ02.0VUE	small SUV	6	20	24	22	5	No	412
VOLKSWAGEN Tiguan	2	4	SemiAuto-6	2WD	Gasoline	CA	U2	California LEV-II ULEV	HVGAJ02.0VUE	small SUV	6	20	24	22	5	No	412
VOLKSWAGEN Tiguan 4Motion	2	4	SemiAuto-6	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HVGAJ02.0VUE	small SUV	6	20	24	21	4	No	421
VOLKSWAGEN Tiguan 4Motion	2	4	SemiAuto-6	4WD	Gasoline	CA	U2	California LEV-II ULEV	HVGAJ02.0VUE	small SUV	6	20	24	21	4	No	421
VOLKSWAGEN Tiguan 4Motion	2	4	SemiAuto-6	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HVGAT02.0VUD	small SUV	6	20	24	21	4	No	421
VOLKSWAGEN Tiguan 4Motion	2	4	SemiAuto-6	4WD	Gasoline	CA	U2	California LEV-II ULEV	HVGAT02.0VUD	small SUV	6	20	24	21	4	No	421
VOLKSWAGEN Touareg	3.6	6	SemiAuto-8	4WD	Gasoline	FA	B5	Federal Tier 2 Bin 5	HVGAT03.6VUK	standard SUV	5	17	23	19	4	No	462
VOLKSWAGEN Touareg	3.6	6	SemiAuto-8	4WD	Gasoline	CA	U2	California LEV-II ULEV	HVGAT03.6VUK	standard SUV	6	17	23	19	4	No	462
VOLKSWAGEN e-Golf	N/A	N/A	Auto-1	2WD	Electricity	FA	T3B0	Federal Tier 3 Bin 0	HVGAV00.0VZZ	small car	10	126	111	119	10	Elite	0
VOLVO S60	2	4	SemiAuto-8	2WD	Gasoline	CA	L3SULEV30	California LEV-III SULEV30	HVVXV02.0S3T	small car	8	25	36	29	7	Yes	302
VOLVO S60	2	4	SemiAuto-8	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	HVVXV02.0S3T	small car	8	25	36	29	7	Yes	302
VOLVO S60	2	4	SemiAuto-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HVVXJ02.0U3T	small car	6	22	32	26	6	No	345
VOLVO S60	2	4	SemiAuto-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HVVXJ02.0U3T	small car	6	23	31	26	6	No	343
VOLVO S60	2	4	SemiAuto-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HVVXJ02.0U3T	small car	6	22	32	26	6	No	345
VOLVO S60	2	4	SemiAuto-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HVVXJ02.0U3T	small car	6	23	31	26	6	No	343
VOLVO S60 CC	2	4	SemiAuto-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HVVXJ02.0U3T	small car	6	22	30	25	5	No	354
VOLVO S60 CC	2	4	SemiAuto-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HVVXJ02.0U3T	small car	6	22	30	25	5	No	354
VOLVO S60 Inscription	2	4	SemiAuto-8	2WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HVVXJ02.0U3T	small car	6	25	36	29	7	Yes	302
VOLVO S60 Inscription	2	4	SemiAuto-8	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HVVXJ02.0U3T	small car	6	25	36	29	7	Yes	302
VOLVO S60 Inscription	2	4	SemiAuto-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HVVXJ02.0U3T	small car	6	23	31	26	6	No	343
VOLVO S60 Inscription	2	4	SemiAuto-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HVVXJ02.0U3T	small car	6	23	31	26	6	No	343
VOLVO S60 Polestar	2	4	SemiAuto-8	4WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HVVXV02.0L3T	small car	5	20	27	23	5	No	388
VOLVO S60 Polestar	2	4	SemiAuto-8	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HVVXV02.0L3T	small car	5	20	27	23	5	No	388

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Model	Displ	Cyl	Trans	Drive	Fuel	Cert Region	Stnd	Stnd Description	Underhood ID	Veh Class	Air Pollution Score	City MPG	Hwy MPG	Cmb MPG	Greenhouse Gas Score	SmartWay	Comb CO2
VOLVO S90	2	4	SemiAuto-8	2WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HVVXJ02.0U3T	midsize car	6	23	34	27	6	No	328
VOLVO S90	2	4	SemiAuto-8	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HVVXJ02.0U3T	midsize car	6	23	34	27	6	No	328
VOLVO S90	2	4	SemiAuto-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HVVXJ02.0U3T	midsize car	6	22	31	25	5	No	353
VOLVO S90	2	4	SemiAuto-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HVVXJ02.0U3T	midsize car	6	22	31	25	5	No	353
VOLVO V60	2	4	SemiAuto-8	2WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HVVXJ02.0U3T	station wagon	6	25	36	29	7	Yes	302
VOLVO V60	2	4	SemiAuto-8	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HVVXJ02.0U3T	station wagon	6	25	36	29	7	Yes	302
VOLVO V60	2	4	SemiAuto-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HVVXJ02.0U3T	station wagon	6	22	32	26	6	No	345
VOLVO V60	2	4	SemiAuto-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HVVXJ02.0U3T	station wagon	6	23	31	26	6	No	343
VOLVO V60	2	4	SemiAuto-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HVVXJ02.0U3T	station wagon	6	22	32	26	6	No	345
VOLVO V60	2	4	SemiAuto-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HVVXJ02.0U3T	station wagon	6	23	31	26	6	No	343
VOLVO V60 CC	2	4	SemiAuto-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HVVXJ02.0U3T	station wagon	6	22	30	25	5	No	354
VOLVO V60 CC	2	4	SemiAuto-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HVVXJ02.0U3T	station wagon	6	22	30	25	5	No	354
VOLVO V60 Polestar	2	4	SemiAuto-8	4WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	HVVXV02.0L3T	station wagon	5	20	27	23	5	No	388
VOLVO V60 Polestar	2	4	SemiAuto-8	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	HVVXV02.0L3T	station wagon	5	20	27	23	5	No	388
VOLVO V90 CC	2	4	SemiAuto-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HVVXJ02.0U3T	station wagon	6	22	30	25	5	No	355
VOLVO V90 CC	2	4	SemiAuto-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HVVXJ02.0U3T	station wagon	6	22	30	25	5	No	355
VOLVO XC 60	2	4	SemiAuto-8	2WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HVVXJ02.0U3T	small SUV	6	23	30	26	6	No	348
VOLVO XC 60	2	4	SemiAuto-8	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HVVXJ02.0U3T	small SUV	6	23	30	26	6	No	348
VOLVO XC 60	2	4	SemiAuto-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HVVXJ02.0U3T	small SUV	6	20	27	22	5	No	395
VOLVO XC 60	2	4	SemiAuto-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HVVXJ02.0U3T	small SUV	6	20	29	23	5	No	384
VOLVO XC 60	2	4	SemiAuto-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HVVXJ02.0U3T	small SUV	6	20	27	22	5	No	395
VOLVO XC 60	2	4	SemiAuto-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HVVXJ02.0U3T	small SUV	6	20	29	23	5	No	384
VOLVO XC 90	2	4	SemiAuto-8	2WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HVVXT02.0U3T	standard SUV	6	22	26	24	5	No	373
VOLVO XC 90	2	4	SemiAuto-8	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HVVXT02.0U3T	standard SUV	6	22	26	24	5	No	373
VOLVO XC 90	2	4	SemiAuto-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HVVXT02.0U3T	standard SUV	6	20	25	22	5	No	399

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Model Year 2017 Green Vehicle Guide

(Limited to releasable data submitted earlier than 02/15/2017)

Model	Displ	Cyl	Trans	Drive	Fuel	Cert Region	Stnd	Stnd Description	Underhood ID	Veh Class	Air Pollution Score	City MPG	Hwy MPG	Cmb MPG	Greenhouse Gas Score	SmartWay	Comb CO2
VOLVO XC 90	2	4	SemiAuto-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	HVVXT02.0U3T	standard SUV	6	22	25	23	5	No	384
VOLVO XC 90	2	4	SemiAuto-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HVVXT02.0U3T	standard SUV	6	20	25	22	5	No	399
VOLVO XC 90	2	4	SemiAuto-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	HVVXT02.0U3T	standard SUV	6	22	25	23	5	No	384
VOLVO XC 90	2	4	SemiAuto-8	4WD	Gasoline/Electricity	CA	L3SULEV30/PZEV	California LEV-III SULEV30/PZEV	HVVXT02.0P3T	standard SUV	9	24/53	27/55	25/54	8	Yes	238
VOLVO XC 90	2	4	SemiAuto-8	4WD	Gasoline/Electricity	FA	T3B30	Federal Tier 3 Bin 30	HVVXT02.0P3T	standard SUV	8	24/53	27/55	25/54	8	Yes	238

*Vehicles may be added throughout the model year. Please check back for updates.

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Light-Duty Automotive Technology,
Carbon Dioxide Emissions, and
Fuel Economy Trends:
1975 Through 2016

Trends

Report

NOTICE:

This technical report does not necessarily represent final EPA decisions or positions. It is intended to present technical analysis of issues using data that are currently available. The purpose in the release of such reports is to facilitate the exchange of technical information and to inform the public of technical developments.

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1 Introduction

Trends is the authoritative reference for CO_2 emissions, fuel economy, and technology trends in the automotive industry from MY 1975-2016

The data supporting this report were obtained by the U.S. Environmental Protection Agency (EPA), directly from automobile manufacturers, in support of EPA's greenhouse gas (GHG) emissions and the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) Corporate Average Fuel Economy (CAFE) programs. These data have been collected and maintained by EPA since 1975, and comprise the most comprehensive database of its kind. This report (the *"Trends report"*) has been published annually since 1975 to summarize trends in EPA's best estimate of **real world** tailpipe CO_2 emissions and fuel economy, and associated technologies. While based on the same underlying data, the Trends report does **not** provide compliance values.

All data are based on annual production volumes of **new** personal vehicles delivered for sale in the United States by model year (MY), which may vary from publicized data based on calendar year sales. Vehicles covered include all passenger cars, sport utility vehicles, minivans, and all but the largest pickup trucks and vans. Section 2 gives an overview of fleetwide trends, while Sections 3 and 4 report trends by vehicle class, type, attribute, manufacturer, and make. Trends in new and conventional technologies are examined in Sections 5 through 8. Additional details and regulatory context are given in Sections 9 and 10.

Trends Database Features

- **Data for MY 1975 through 2015 are final.** These data are submitted to the EPA and NHTSA at the conclusion of the model year and include actual production data and the results of emission and fuel economy testing performed by the manufacturers and EPA.

- **Data for MY 2016 are preliminary.** These data are based on projected production data provided to EPA by automakers for vehicle certification and labeling prior to MY 2016 sales. MY 2016 values will be finalized in next year's report.

- **Data from alternative fuel vehicles (AFVs) are integrated into the overall database, beginning with MY 2011 data.** These vehicles include electric vehicles, plug in hybrids, fuel cell vehicles, and compressed natural gas vehicles.

- **Most data are reported as fleetwide averages.** Most of the data in this report reflect arithmetic production-weighted averages of individual CO_2 emissions values and harmonic production-weighted averages of individual fuel economy values.

It is important to note that the Department of Justice, on behalf of EPA, alleged violations of the Clean Air Act by Volkswagen and certain subsidiaries based on the sale of certain MY 2009-2016 diesel vehicles equipped with software designed to cheat on federal emissions tests. In this report, EPA uses the CO_2 emissions and fuel economy data from the initial certification of these vehicles. Should the investigation and corrective actions yield different CO_2 and fuel economy data, the revised data will be used in future reports. For more information on actions to resolve these violations, see www.epa.gov/vw.

Understanding the Trends Database

The primary CO_2 and fuel economy data in the Trends report are **adjusted** values that represent EPA's best estimates of **real world** performance. The adjusted data for this report are based on the same underlying data submitted to EPA for the both the consumer Label and the CAFE and GHG compliance programs, but there are some important differences.

Unadjusted, laboratory values are used to determine automaker **compliance** with the standards, along with various regulatory incentives and credits. These values are measured with EPA's City and Highway Test procedures (the "2-cycle" tests). A combined city/ highway value is then calculated using a 55%/45% city-highway weighted average. These unadjusted, laboratory values do not fully represent real world driving, but are occasionally presented in this report because they provide a consistent baseline for comparing trends in vehicle design over time.

The consumer data reported on the EPA/DOT Fuel Economy and Environment Labels ("window stickers") use a more realistic "5-cycle" test procedure intended to better reflect real world performance. The combined city/highway Label values use the 55%/45% city-highway weighting. The adjusted values in the Trends report are also derived from 5-cycle test values, but use a city-highway weighting of 43%/57% consistent with fleetwide driver activity data.

CO_2 and Fuel Economy Data Type	Purpose	City/Highway Weighting	Test Basis
Adjusted	Best estimate of real world performance	43% / 57%	5-cycle
Label	Consumer information to compare individual vehicles	55% / 45%	5-cycle
Unadjusted, Laboratory	Basis for automaker compliance with standards	55% / 45%	2-cycle

Adjusted CO_2 emissions values are, on average, about 25% higher than unadjusted CO_2 values, and adjusted fuel economy values are about 20% lower than unadjusted fuel economy values.

Since major methodological changes are generally propagated backwards through the historical database in order to maintain the integrity of long-term trends, this report supersedes previous versions in the series and should not be compared to past reports. See Section 10 for a detailed methodological explanation of fuel economy and CO_2 values and calculations throughout the historical database.

For Additional Information:
- Access the Trends report online: www.epa.gov/fuel-economy/trends-report
- *Manufacturer Performance Report for the 2015 Model Year:* www.epa.gov/regulations-emissions-vehicles-and-engines/ghg-emission-standards-light-duty-vehicles-manufacturer
- NHTSA's CAFE Public Information Center: www.nhtsa.gov/CAFE_PIC

This section provides an overview of important fleetwide data for MY 1975-2016, including a reference table for CO_2 emissions, fuel economy, and other key parameters. Fleetwide refers to the production-weighted analysis of *new* vehicles produced for the U.S. fleet. Alternative fuel vehicle data is integrated with data for gasoline vehicles and diesel vehicles. CO_2 emissions from alternative fuel vehicles represent tailpipe emissions, while fuel economy for alternative fuel vehicles is reported as miles per gallon of gasoline equivalent, or mpge, the miles an alternative fuel vehicle can travel on an amount of energy equivalent to that in a gallon of gasoline. Unless otherwise noted, all CO_2 emissions and fuel economy data are adjusted values that reflect real world performance, and are not comparable to unadjusted, laboratory values that are the basis for EPA GHG emissions and NHTSA CAFE standards compliance. Subsequent sections of the report analyze the Trends data in more detail.

A. Overview of Final MY 2015 Data

Table 2.1 shows that the fleetwide average real world CO_2 emissions rate for new vehicles produced in MY 2015 is 358 grams per mile (g/mi), a drop of 8 g/mi from MY 2014. The MY 2015 fuel economy value is 24.8 miles per gallon (mpg), an increase of 0.5 mpg from MY 2014. These MY 2015 values are based on final data and represent a new record low for CO_2 emissions and a record high for fuel economy. Over the last ten years, CO_2 emissions and fuel economy have improved eight times and worsened once.

Truck production share of the overall personal vehicle market increased by 2 percentage points in MY 2015. Car and truck production share has been volatile in recent years, and has had significant impacts on other parameters. Average personal vehicle weight decreased by 25 pounds (0.6%) in MY 2015 to 4035 pounds. Average power decreased by 1 horsepower (0.4%) to 229 horsepower, just below the all-time high reached in MY 2011 and MY 2014. Average vehicle footprint decreased from MY 2014 by 0.3 square feet (0.6%) to 49.4 square feet.

Tables 3.4.1 and 3.4.2, shown later in this report, disaggregate the data in Table 2.1 for the individual car and truck fleets, respectively, for MY 1975-2016.

B. Overview of Preliminary MY 2016 Data

Preliminary MY 2016 adjusted fleetwide average CO_2 emissions is 347 g/mi with a corresponding fuel economy value of 25.6 mpg. If achieved, these values will be record levels and an improvement over MY 2015. The preliminary MY 2016 data suggest that truck production share will fall almost 5 percentage points. Horsepower is projected to remain near record highs, footprint is projected to drop slightly, and weight is projected to drop by about 50 pounds.

Table 2.1

Adjusted CO_2 Emissions, Adjusted Fuel Economy, and Key Parameters by Model Year[1]

Model Year	Production (000)	Adj CO_2 (g/mi)	Adj Fuel Economy (MPG)	Weight (lbs)	HP	Footprint (sq ft)	Car Production	Truck Production	Alternative Fuel Vehicle Share of Production
1975	10,224	681	13.1	4060	137	--	80.7%	19.3%	--
1976	12,334	625	14.2	4079	135	-	78.9%	21.1%	-
1977	14,123	590	15.1	3982	136	·	80.1%	19.9%	·
1978	14,448	562	15.8	3715	129	--	77.5%	22.5%	-
1979	13,882	560	15.9	3655	124	--	77.9%	22.1%	--
1980	11,306	466	19.2	3228	104	--	83.5%	16.5%	--
1981	10,554	436	20.5	3202	102	·	82.8%	17.2%	·
1982	9,732	425	21.1	3202	103	-	80.5%	19.5%	-
1983	10,302	426	21.0	3257	107	--	78.0%	22.0%	--
1984	14,020	424	21.0	3262	109	--	76.5%	23.5%	--
1985	14,460	417	21.3	3271	114	·	75.2%	24.8%	·
1986	15,365	407	21.8	3238	114	-	72.1%	27.9%	-
1987	14,865	405	22.0	3221	118	-	72.8%	27.2%	-
1988	15,295	407	21.9	3283	123	--	70.9%	29.1%	--
1989	14,453	415	21.4	3351	129	-	70.1%	29.9%	-
1990	12,615	420	21.2	3426	135	-	70.4%	29.6%	-
1991	12,573	418	21.3	3410	138	--	69.6%	30.4%	-
1992	12,172	427	20.8	3512	145	--	68.6%	31.4%	--
1993	13,211	426	20.9	3519	147	-	67.6%	32.4%	0.0%
1994	14,125	436	20.4	3603	152	-	61.9%	38.1%	0.0%
1995	15,145	434	20.5	3613	158	--	63.5%	36.5%	0.0%
1996	13,144	435	20.4	3659	164	--	62.2%	37.8%	0.0%
1997	14,458	441	20.2	3727	169	-	60.1%	39.9%	0.0%
1998	14,456	442	20.1	3744	171	·	58.3%	41.7%	0.0%
1999	15,215	451	19.7	3835	179	--	58.3%	41.7%	0.0%
2000	16,571	450	19.8	3821	181	--	58.8%	41.2%	0.0%
2001	15,605	453	19.6	3879	187	-	58.6%	41.4%	0.0%
2002	16,115	457	19.5	3951	195	·	55.2%	44.8%	0.0%
2003	15,773	454	19.6	3999	199	--	53.9%	46.1%	0.0%
2004	15,709	461	19.3	4111	211	--	52.0%	48.0%	0.0%
2005	15,892	447	19.9	4059	209	-	55.6%	44.4%	0.0%
2006	15,104	442	20.1	4067	213	·	57.9%	42.1%	0.0%
2007	15,276	431	20.6	4093	217	·	58.9%	41.1%	0.0%
2008	13,898	424	21.0	4085	219	48.9	59.3%	40.7%	0.0%
2009	9,316	397	22.4	3914	208	48.1	67.0%	33.0%	0.0%
2010	11,116	394	22.6	4001	214	48.5	62.8%	37.2%	0.0%
2011	12,018	397	22.4	4126	230	49.5	57.8%	42.2%	0.1%
2012	13,448	375	23.7	3979	222	48.8	64.4%	35.6%	0.4%
2013	15,198	366	24.3	4003	226	49.1	64.1%	35.9%	0.7%
2014	15,512	366	24.3	4060	230	49.7	59.3%	40.7%	0.7%
2015	16,739	358	24.8	4035	229	49.4	57.4%	42.6%	0.7%
2016 (prelim)	-	347	25.6	3985	229	49.3	62.1%	37.9%	1.7%

[1] Adjusted CO_2 and fuel economy values reflect real world performance and are not comparable to automaker standards compliance levels. Adjusted CO_2 values are, on average, about 25% higher than the unadjusted, laboratory CO_2 values that form the starting point for GHG standards compliance, and adjusted fuel economy values are about 20% lower, on average, than unadjusted fuel economy values.

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We caution the reader about focusing on these preliminary MY 2016 values. The production estimates for these values were provided to EPA by automakers in 2015, and there is always uncertainty associated with such projections. This uncertainty is magnified this year as U.S. gasoline prices have remained low and consumer preference continues to move towards sport utility vehicles (SUVs) and larger vehicles. Final values for MY 2016, based on actual production values, will be published in next year's report.

C. OVERVIEW OF LONG-TERM TRENDS

While the most recent annual changes often receive the most public attention, the greatest value of the Trends database is to document long-term trends. This is because: 1) year-to-year variability can reflect short-term trends (two examples are the Cash for Clunkers rebates in 2009 and the impact of the tsunami aftermath on Japan-based manufacturers in 2011) that may not be meaningful from a long-term perspective, and 2) the magnitude of year-to-year changes in annual CO_2 emissions and fuel economy tend to be small relative to longer, multi-year trends.

Figures 2.1 and 2.2 show fleetwide adjusted CO_2 emissions and fuel economy from Table 2.1 for MY 1975-2016. For both figures, the individual data points represent annual values, and the curves represent 3-year moving averages (where each year represents the average of that model year, the model year prior, and the model year following, e.g., the value for MY 2015 represents the average of MY 2014-2016) which "smooth out" the year-to-year volatility. The two curves are essentially inversely proportional to each other, i.e., vehicle tailpipe CO_2 emissions (grams per mile) are proportional to fuel consumption (gallons per mile), which is the reciprocal of fuel economy (miles per gallon).

These two figures show that fleetwide adjusted CO_2 emissions and fuel economy have undergone four clearly defined phases since 1975. Figure 2.3 shows fleetwide adjusted fuel economy, weight, and horsepower data for MY 1975-2016 from Table 2.1. All of the data in Figure 2.3 are presented as percentage changes since 1975. It's important to note, other things being equal, that vehicle weight and horsepower increases are generally associated with increased CO_2 emissions and decreased fuel economy.

Figure 2.1

Adjusted CO₂ Emissions by Model Year
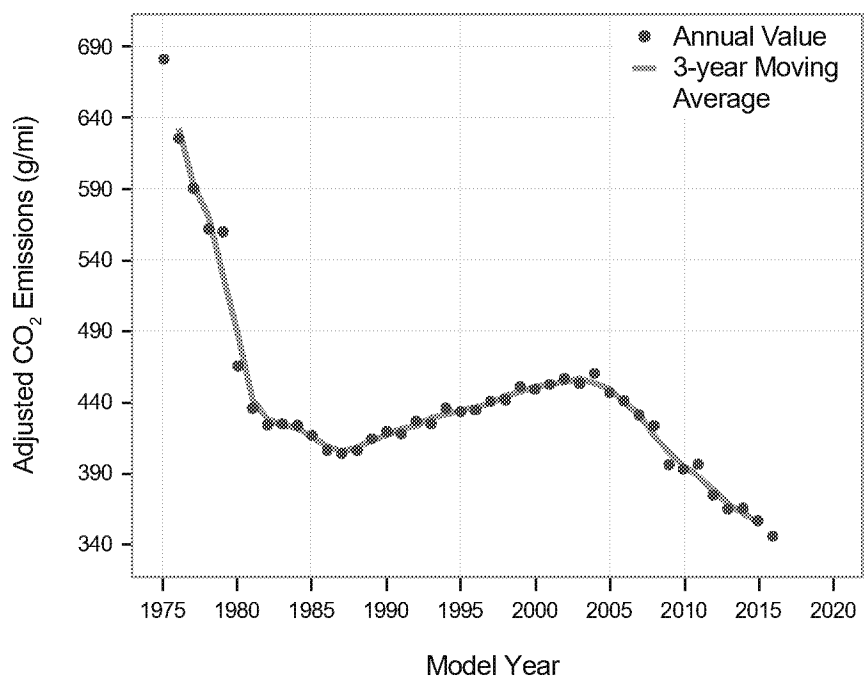
Figure 2.2

Adjusted Fuel Economy by Model Year

Figure 2.3

Change in Adjusted Fuel Economy, Weight, and Horsepower Since 1975
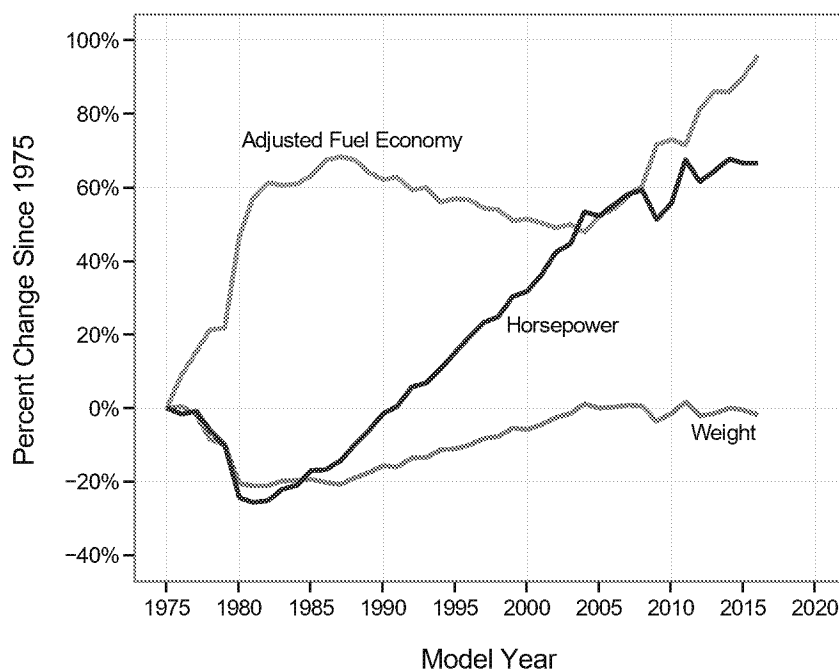
Figure 2.3 shows some very significant long-term trends. Both average vehicle weight and horsepower decreased in the late 1970s as fuel economy increased. During the two decades from the mid-1980s to the mid-2000s, vehicle weight and horsepower rose consistently and significantly, while fleetwide fuel economy slowly and steadily decreased. It is clear from Figure 2.3 that the considerable technology innovation during these two decades, on a fleet-wide basis, supported attributes such as vehicle weight and power (and associated utility functions such as vehicle size, acceleration performance, safety features and content), but did not improve fuel economy. Since MY 2005, new automotive technology has improved fuel economy while keeping vehicle weight relatively constant. Horsepower has generally increased,

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but may be flattening out. As a result, recent vehicles have greater acceleration performance, higher fuel economy, and lower CO_2 emissions.

Table 2.1 also shows data for vehicle footprint. Footprint is a critical vehicle attribute since it is the basis for current and future GHG emissions and fuel economy standards. The Trends database includes footprint data from informal, external sources beginning in MY 2008 and from data provided directly by automakers since MY 2011. Average footprint has fluctuated between MY 2008 and MY 2015. Footprint trends are explored in more detail in Section 3.

Table 2.1 does not include 0-to-60 time acceleration data, which are not provided by automakers and are calculated by EPA using equations from the literature. See Section 3.D for 0-to-60 acceleration time projections, as well as for more detail on weight, horsepower, and footprint data.

Table 2.1 also shows that truck share increased consistently from 1980 through 2004. The truck share increases from 1988 through 2004 were a critical underlying factor in the increase in fleetwide weight and power discussed above, as well as in the higher fleetwide CO_2 emissions and lower fleetwide fuel economy over that same period. Since 2004, truck share has been volatile, affected by factors such as the economic recession of 2009, the Car Allowance Rebate System (also known as Cash for Clunkers) in 2009, and the aftermath of the earthquake and tsunami in Japan in 2011. For more data and discussion of relative car/truck production share, as well as data for the separate car and truck fleets, see Section 3.

Table 2.2 shows a comparison, for fuel economy and several other key attributes, of final MY 2015 data with MY 2008 and MY 2004 data.

MY 2008 is selected for comparison for three reasons: 1) several years provide a sufficient time to see meaningful multi-year trends, 2) it preceded a multi-year period of variability beginning in MY 2009, and 3) there have only been relatively minor changes in key vehicle attributes that influence fuel economy in the six years that followed. From MY 2008 to MY 2015, weight decreased by 1.2% (which would be expected to result in a slight increase in fuel economy, other things being equal), while horsepower increased by 4.7% and footprint increased by 1.1% (both of which would be expected to result in a decrease in fuel economy). Fuel economy, on the other hand, increased by 3.9 mpg, or 18%, from MY 2008 to MY 2015.

MY 2004 is shown in Table 2.2 primarily because it is the "valley year," i.e., it is the year with the lowest adjusted fuel economy since MY 1980 and therefore now represents a 34-year low. As with the comparison of MY 2008 and MY 2015 above, the changes in weight and horsepower from MY 2004 to MY 2015 have gone in opposite directions—weight has decreased by 1.8% and horsepower has increased by 8.7%. We do not have footprint data for MY 2004. From MY 2004 to MY 2015, fuel economy has increased by 5.5 mpg, or 29%. The only other period with a greater and more rapid fuel economy increase was from MY 1975 through MY 1981, driven by higher oil and gasoline prices and the initial CAFE standards.

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Table 2.2 also shows fuel savings that would accrue to consumers who owned and operated average MY 2015 vehicles relative to MY 2008 and MY 2004 vehicles. Table 2.2 is based on the assumptions used to generate the 5-year savings/cost values shown on current Fuel Economy and Environment Labels: consumer operates the new vehicle for five years, averaging 15,000 miles per year, gasoline prices of $2.45 per gallon[2], and no discounting to reflect the time value of money (of course, people can drive more or less miles per year and gasoline prices can vary significantly). As shown in Table 2.2, the 3.8 mpg increase in average fuel economy from MY 2008 to MY 2015 would save a typical consumer $1300 over five years, and the 5.5 mpg increase from MY 2004 to MY 2015 would save the same consumer $2100.

Table 2.2

Comparison of MY 2015 with MY 2008 and MY 2004*

MY 2015 Relative to MY 2008

Adjusted Fuel Economy	5-Year Fuel Savings	Weight	Horsepower	Footprint
+3.9 MPG +18%	$1,300	-1.2%	+4.7%	+1.1%

MY 2015 Relative to MY 2004

Adjusted Fuel Economy	5-Year Fuel Savings	Weight	Horsepower	Footprint
+5.5 MPG +29%	$2,100	-1.8%	+8.7%	-

*Note: some of the % values in this table may differ slightly from calculations based on the absolute values in Table 2.1 due to rounding.

Figure 2.4 shows the production-weighted distribution of adjusted fuel economy by model year, for gasoline (including conventional hybrids) and diesel vehicles. Alternative fuel vehicles are excluded, as they would otherwise dominate this list as many achieve 100 mpge or greater. It is important to note that the methodology used in this report for calculating adjusted fuel economy values has changed over time (see Section 10 for a detailed explanation). For example, the adjusted fuel economy for a 1980s vehicle in the Trends database is somewhat higher than it would be if the same vehicle were being produced today as the methodology for calculating adjusted values has changed over time to reflect real world vehicle operation. These changes are small for most vehicles, but larger for extremely high fuel economy vehicles. For example, the "Best Car" line in Figure 2.4 for MY 2000 through MY 2006 represents the original Honda Insight hybrid, and the several miles per gallon decrease over that period is primarily due to the change in methodology for adjusted fuel economy values, with just a 1 mpg decrease due to minor vehicle design changes during that time.

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[2] Annual fuel cost estimate for regular gasoline, in accordance with EPA's labeling guidance for MY 2017 vehicles (CD-15-27)

Figure 2.4

Adjusted Fuel Economy Distribution by Model Year, AFVs Excluded
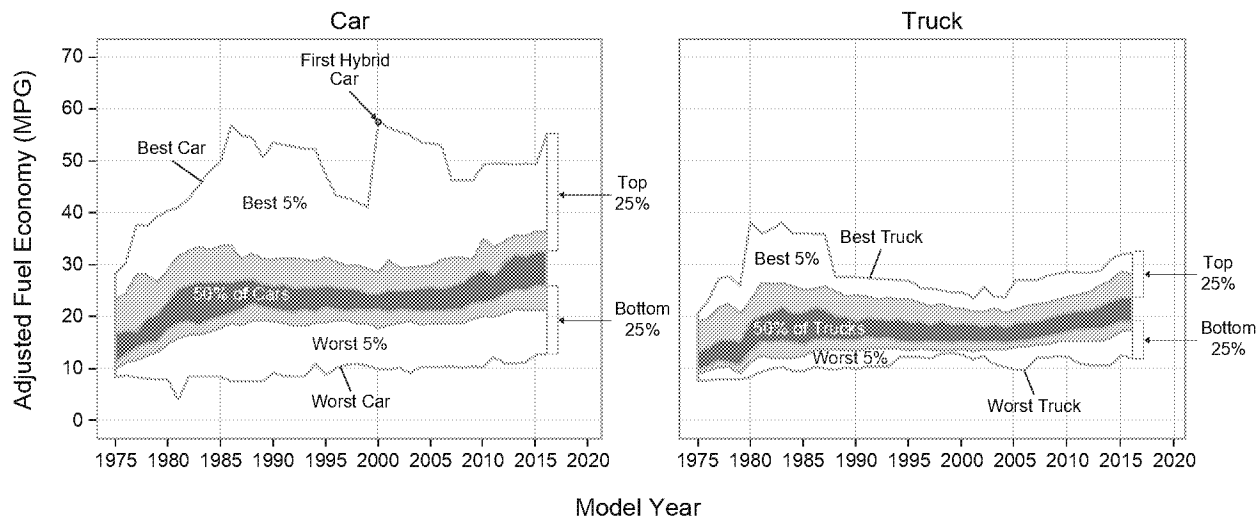
Since 1975, half of car production has consistently been within several mpg of each other. The fuel economy difference between the least efficient and most efficient car increased from about 20 mpg in MY 1975 to nearly 50 mpg in MY 1986 (when the most efficient car was the General Motors Sprint ER) and in MY 2000 (when the most efficient car was the original Honda Insight hybrid), and is now about 40 mpg. Hybrids have defined the "Best Car" line since MY 2000. The ratio of the highest-to-lowest fuel economy value has increased from about three-to-one in MY 1975 to nearly five-to-one today, as the fuel economy of the least fuel efficient cars has remained roughly constant in comparison to the most fuel efficient cars whose fuel economy has nearly doubled since MY 1975.

The overall fuel economy distribution for trucks is narrower than that for cars, with a peak in the fuel economy of the most efficient truck in the early 1980s when small pickup trucks equipped with diesel engines were sold by Volkswagen and General Motors. As a result, the fuel economy range between the most efficient and least efficient truck peaked at about 25 mpg in the early 1980s. The fuel economy range for trucks then narrowed, and is now about 20 mpg. Like cars, half of the trucks built each year have always been within a few mpg of each year's average fuel economy value.

All of the above data are adjusted, combined city/highway CO_2 emissions and fuel economy values for the combined car and truck fleet. Table 10.1 provides, for the overall car and truck fleets, adjusted and unadjusted, laboratory values for city, highway, and combined city/highway. Appendices B and C provide more detailed data on the distribution of adjusted fuel economy values by model year.

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Table 2.3 shows the highest fuel economy gasoline and diesel vehicles for the MY 1975-2016 time frame (while the Trends report database began in MY 1975, we are confident that these are also the highest fuel economy values of all time for mainstream vehicles in the U.S. market). Note that alternative fuel vehicles, such as electric and plug-in hybrid electric vehicles, are excluded from this table (see Section 7 for information on alternative fuel vehicles). See Appendix A for a listing of the highest and lowest fuel economy vehicles, based on unadjusted fuel economy values, for each year since 1975.

Unadjusted, laboratory fuel economy (weighted 55% city/45% highway) values are used to rank vehicles in Table 2.3, since the test procedures and methodology for determining unadjusted, laboratory fuel economy values have remained largely unchanged since 1975. Accordingly, unadjusted, laboratory values provide a more equitable fuel economy metric, from a vehicle design perspective, over the historical time frame, than the adjusted fuel economy values used throughout most of this report, as the latter also reflect changes in real world driving behavior such as speed, acceleration, and use of air conditioning.

For Table 2.3, vehicle models with the same powertrain and essentially marketed as the same vehicle to consumers are shown only once, as are "twins" where very similar vehicle designs are marketed by two or more makes or brands. Models are typically sold for several years before being redesigned, so the convention for models with the same fuel economy for several years is to show MY 2016, if applicable, and otherwise to show the first year when the model achieved its maximum fuel economy. Data are also shown for number of seats and inertia weight class.

Table 2.3
Top Ten Highest Unadjusted, Laboratory Fuel Economy Gasoline/Diesel Vehicles Since 1975

Model Year	Manufacturer	Make	Model	Powertrain	Unadjusted, Laboratory Combined Fuel Economy (MPG)	Number of Seats	Inertia Weight Class (lbs)
2016	Toyota	Toyota	Prius Eco	Gasoline Hybrid	81	5	3000
2000	Honda	Honda	Insight	Gasoline Hybrid	76	2	2000
2016	Toyota	Toyota	Prius	Gasoline Hybrid	74	5	3500
2016	Toyota	Toyota	Prius c	Gasoline Hybrid	71	5	2750
2015	Honda	Honda	Accord	Gasoline Hybrid	70	5	4000
1986	GM	Chevrolet	Sprint ER	Conv. Gasoline	67	4	1750
1994	GM	Geo	Metro XFi	Conv. Gasoline	66	4	1750
1986	Honda	Honda	Civic CRX HF	Conv. Gasoline	64	2	2000
2015	Honda	Honda	Civic Hybrid	Gasoline Hybrid	64	5	3000
2016	GM	Chevrolet	Malibu	Gasoline Hybrid	61	5	3500

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As expected, all of the vehicles listed in Table 2.3 are cars. Somewhat more surprisingly, no diesel cars made the list.[3] The top fuel economy vehicle is the new MY 2016 Toyota Prius Eco, which achieved an unadjusted, laboratory value of 81 mpg. The second most efficient vehicle is the MY 2000 Honda Insight, a two-seater that was the first hybrid vehicle sold in the U.S. market.

Six of the highest ten fuel economy vehicles of all time are on the market in MY 2016 or MY 2015[4], and all of these are conventional hybrids. Other than the MY 2000 Insight, also a conventional hybrid, the remaining three vehicles in Table 2.3 are non-hybrid gasoline vehicles from the late 1980s and early 1990s. The non-hybrid vehicle with the highest fuel economy is the 1986 Chevrolet Sprint ER with an unadjusted, laboratory fuel economy of 67 mpg.

One of the most important lessons from Table 2.3 is that there are important differences between the highest fuel economy vehicles of the past and those of today. All of the pre-MY 2015 vehicles in Table 2.3 had 2 or 4 seats, while the MY 2015 vehicles all seat 5 passengers. The older vehicles had inertia weight class values of 1750-2000 pounds, while the MY 2015 vehicles are in inertia weight classes of 2750-4000 pounds, or 1000-2000 pounds heavier. Though not shown in Table 2.3, the MY 2016 vehicles also have faster acceleration rates and are also required to meet more stringent EPA emissions standards and DOT safety standards than vehicles produced in the earlier model years. One clear conclusion from Table 2.3 is that conventional hybrid technology has enabled manufacturers to offer high fuel economy vehicles with much greater utility, while simultaneously meeting more stringent emissions and safety standards, than the high fuel economy vehicles of the past.

Finally, since all of the vehicles in Table 2.3 are cars, Table 2.4 shows a comparable table for the highest fuel economy gasoline and diesel trucks since MY 1975. The methodological approach for selecting the trucks shown in Table 2.4 is the same as discussed above for cars in Table 2.3. The most fuel efficient gasoline/diesel truck in the historical Trends database is a small Volkswagen diesel pickup truck sold in the early 1980s with an unadjusted, laboratory fuel economy of 45 mpg. Interestingly, this small pickup truck had the same number of seats, and nearly the same inertia weight class, as the most fuel efficient car in Table 2.3, the 2000 Honda Insight. This year, the MY 2016 Toyota RAV4 AWD hybrid rose to second on this list and also achieved an unadjusted, laboratory fuel economy of 45 mpg, only very slightly lower fuel economy than the VW pickup.

The most fuel efficient trucks are a more diverse mix than the most fuel efficient cars—while all three trucks from the 1980s were small diesels, the seven trucks from recent years include five gasoline hybrids, one diesel, and one conventional gasoline, with inertia weight ratings of 3500-5000 pounds. As shown in Table 2.3 for cars, more efficient powertrain technology in

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[3] The most fuel efficient diesel car in the historical Trends database is the Nissan Sentra from the mid-1980s which had an unadjusted, laboratory fuel economy of 56 mpg. The most efficient MY 2016 diesel car is the BMW 328d, which has an unadjusted, laboratory value of 50 mpg.
[4] The Honda Accord hybrid was not available as a MY 2016 model, but press reports indicate it will be reintroduced as a MY 2017 model. The Honda Civic hybrid was apparently cancelled after MY 2015.

the last few years has enabled automakers to offer high fuel economy trucks with greater seating capacity and inertia weight than the high fuel economy diesel trucks of the early 1980s, while simultaneously meeting more stringent emissions and safety standards.

Table 2.4
Top Ten Highest Unadjusted, Laboratory Fuel Economy Gasoline/Diesel Trucks Since 1975

Model Year	Manufacturer	Make	Model	Powertrain	Unadjusted, Laboratory Combined Fuel Economy (MPG)	Number of Seats	Inertia Weight Class (lbs)
1983	VW	VW	Pickup 2WD	Diesel	45	2	2250
2016	Toyota	Toyota	RAV4 AWD	Gasoline Hybrid	45	5	4000
2016	Toyota	Lexus	NX 300h AWD	Gasoline Hybrid	44	5	4500
1982	GM	Chevrolet	Pickup 2WD	Diesel	43	2	2750
2016	Subaru	Subaru	XV Crosstrek AWD	Gasoline Hybrid	42	5	3500
1983	Grumman Olson	Grumman Olson	Kubvan	Diesel	42	2	2250
2016	Toyota	Lexus	RX 450h AWD	Gasoline Hybrid	41	5	5000
2016	BMW	BMW	X3 xDrive28d	Diesel	40	5	4500
2010	Ford	Ford	Escape 4WD	Gasoline Hybrid	39	5	4000
2016	Honda	Honda	HR-V 4WD	Conv. Gasoline	39	5	3500

3 Vehicle Class, Type, and Attributes

A. VEHICLE CLASS

We use "class" to refer to the overall division of light-duty (or personal) vehicles into the two classes of "cars" and "trucks." This car-truck distinction has been recognized since the database was originally created in 1975, though the precise definitions associated with these two classes have changed somewhat over time. Car-truck classification is important both because of functional differences between the design of many cars and trucks, and because there are separate footprint-based CO_2 emissions and fuel economy standards curves for cars and trucks. The regulatory challenge has been where to draw the line between cars and trucks, and this has evolved over time.

Car and truck classifications in this report are based on the current regulatory definitions used by both EPA and NHTSA for CO_2 emissions and CAFE standards. These current definitions are somewhat different than those used in older versions of this report. The most important change was re-classification of many small and mid-sized, 2-wheel drive sport utility vehicles (SUVs) from the truck category to the car category. As with other such changes in this report, this change has been propagated back throughout the entire historical database. This re-classification reduced the absolute truck share by approximately 10% for recent years. A second change was the inclusion of medium-duty passenger vehicles (MDPVs), those SUVs and passenger vans with gross vehicle weight ratings between 8,500 and 10,000 pounds and which previously had been treated as heavy-duty vehicles, into the light-duty truck category. This is a far less important change, since the number of MDPVs is much smaller than it once was (e.g., only an estimated 6,500 MDPVs were produced for sale in MY 2012). In this report, "cars" include passenger cars and most small and mid-sized, 2 wheel-drive SUVs, while "trucks" include all other SUVs and all minivans and vans, and pickup trucks below 8500 pounds gross vehicle weight rating.

Figure 3.1 shows the car and truck production volume shares using the current car-truck definitions throughout the MY 1975-2016 database.

Figure 3.1
Car and Truck Production Share by Model Year
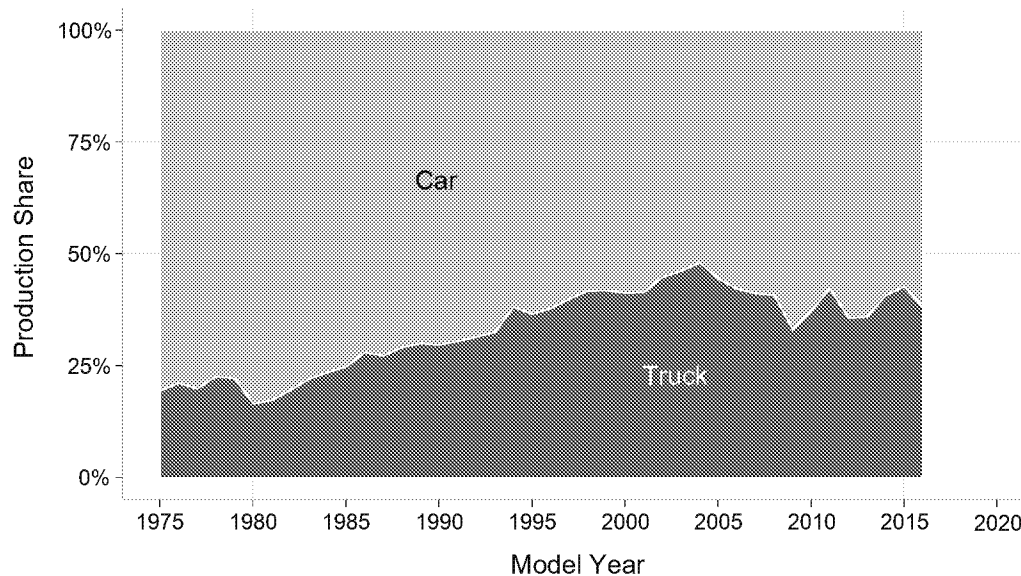
Truck share was around 20% from MY 1975-1982, and then started to increase steadily through MY 2004, when it peaked at 48%. The truck share increases from MY 1988-2004, a period during which inflation-adjusted gasoline prices remained at or near historical lows, were a critical factor in the increased fleetwide CO_2 emissions and decrease in fleetwide fuel economy over that same period. Since 2004, truck share has been volatile, affected by factors such as the economic recession of 2009, the Car Allowance Rebate System (also known as Cash for Clunkers) in 2009, and the earthquake and tsunami aftermath in Japan in 2011.

The final truck share value for MY 2015 is 43%, 2 percentage points higher than in MY 2014 but 5 percentage points lower than the peak truck share of 48% in MY 2004. The preliminary MY 2016 truck market share is projected to decrease slightly to 38%, though this is very uncertain given lower gasoline prices.

B. VEHICLE TYPE

We use vehicle "type" to refer to secondary divisions within the car and truck classes. Vehicle type is not relevant to standards compliance, as all cars (and, separately, all trucks) use the same footprint-CO_2 emissions and footprint-fuel economy target curves, but we believe that certain vehicle type distinctions are illustrative and meaningful from both vehicle design and marketing perspectives.

This report breaks the car class into two types—cars and car SUVs. The truck class is split into three types—truck SUVs, pickups, and minivans/vans. This is a simpler approach than that used in some older versions of this report.

Figure 3.2
Vehicle Classes and Types Used in This Report
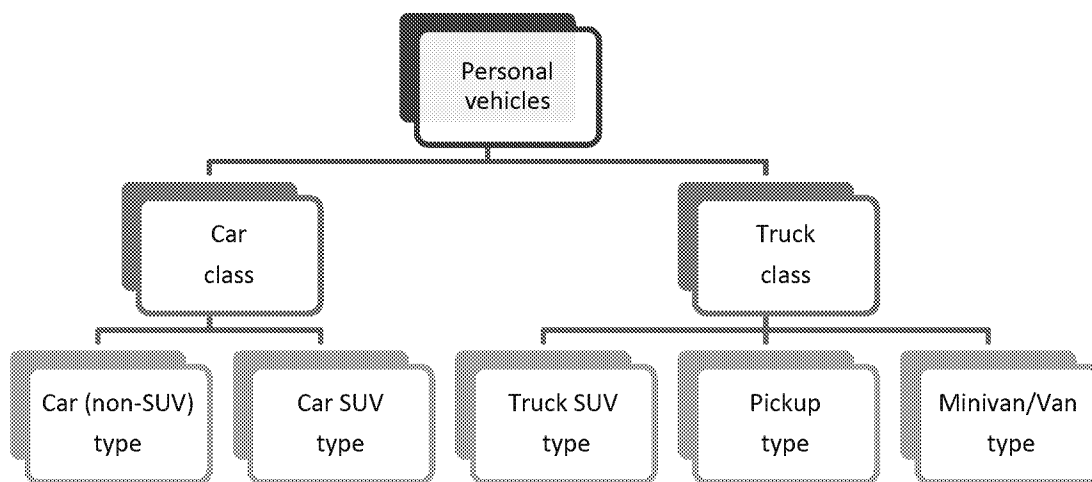
For cars, pre-2013 versions of this report generally divided the car class into as many as 9 types/sizes (Cars, Wagons, and Car SUVs, each further subdivided into small, medium, and large sizes based on interior volume). We no longer use wagons as a car type in this report.

More importantly, we believe that interior volume (the sum of passenger volume and cargo volume, typically measured in cubic feet), the metric that was historically used to differentiate among car type vehicles, is not as informative as it once was. For example, Figure 3.3 shows production share versus interior volume for car type vehicles for two years, MY 1978 and MY 2016, for high-volume manufacturers.

Figure 3.3

Car Type Production Share vs. Interior Volume for High Volume Manufacturers, MY 1978 and MY 2016
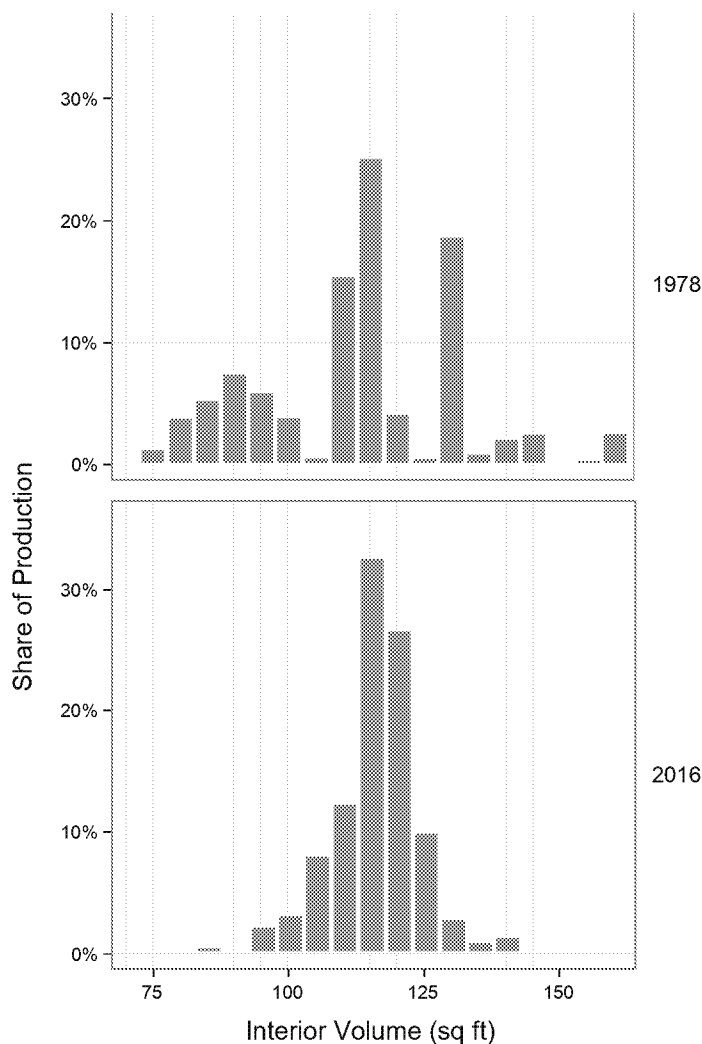
The data in Figure 3.3 illustrate the "compression" in the range of interior volumes for car type vehicles since 1978 (each bar represents a band of 5 cubic feet). Two-seater cars are excluded from this figure as automakers do not provide interior volume data for 2-seaters. In MY 1978, there were mainstream car type vehicles on the market with interior volumes ranging from about 70 cubic feet to about 160 cubic feet, with meaningful production volume at both ends of the spectrum. Today, mainstream offerings range from about 80 cubic feet to about 130 cubic feet (some 4-seat cars in the 55-60 cubic feet interior volume range do not show up in this figure due to very low production volume). The compression is even greater when considering production volumes. We reviewed the data for one high-volume make that offered seven car type models in MY 2012. The interior volume of these seven models ranged from 97-124 cubic feet, with 75% of sales within a very narrow interior volume range of 104-111 cubic feet, and about 50% of production (representing 3 models) with essentially the same interior volume (110-111 cubic feet).

Accordingly, we believe that interior volume is no longer very useful as a differentiator among car type vehicles in the Trends database. We believe that vehicle footprint is a more appropriate indicator of car size because it is the basis for both CO_2 emissions and fuel economy standards (and it is relevant to both cars and trucks). Interior volume data for car type vehicles will still be included in the Trends database.

This report divides the car class into two types: 1) a car SUV type for those SUVs that do not meet the light truck definition and thus must meet the car GHG emissions and fuel economy standards, and 2) a car type for all other vehicles in the car class, including the www.fueleconomy.gov designations of minicompact, subcompact, compact, midsize, large, two-seater cars, and station wagons. For propagating back in the historical database, station wagons are generally allocated to the car type.

For trucks, pre-2013 versions of this report divided the truck class into 9 types/sizes (SUVs, Pickups, and Vans (including minivans), each further subdivided into small, medium, and large sizes based on vehicle wheelbase). This report retains the three historical truck types because we believe that there continue to be meaningful functional and marketing differences between truck SUVs (those SUVs that must meet the truck GHG emissions and fuel economy standards), pickups, and minivans/vans. See Section 10 for the definitions for SUVs, pickups, minivans, and vans and for more information about car-truck classifications. We use engineering judgment to allocate the very small number of special purpose vehicles (as designated on www.fueleconomy.gov) to the three truck types.

It is important to note that this report no longer uses wheelbase to differentiate between truck type sizes. The rationale for this change, similar to that for car interior volume above, is that the wheelbase metric is not as informative as it once was. For example, under the wheelbase thresholds that were used in the 2012 report, 99% of MY 2011 pickups were "large" and 99% of MY 2011 minivans/vans were "medium." In addition, wheelbase is one of the two factors that comprise vehicle footprint (wheelbase times average track width).

Figure 3.4 shows the car and truck production volume shares for MY 1975-2016, subdivided into the two car types and three truck types. Table 3.1 shows the same data in tabular form.

Figure 3.4

Vehicle Type Production Share by Model Year
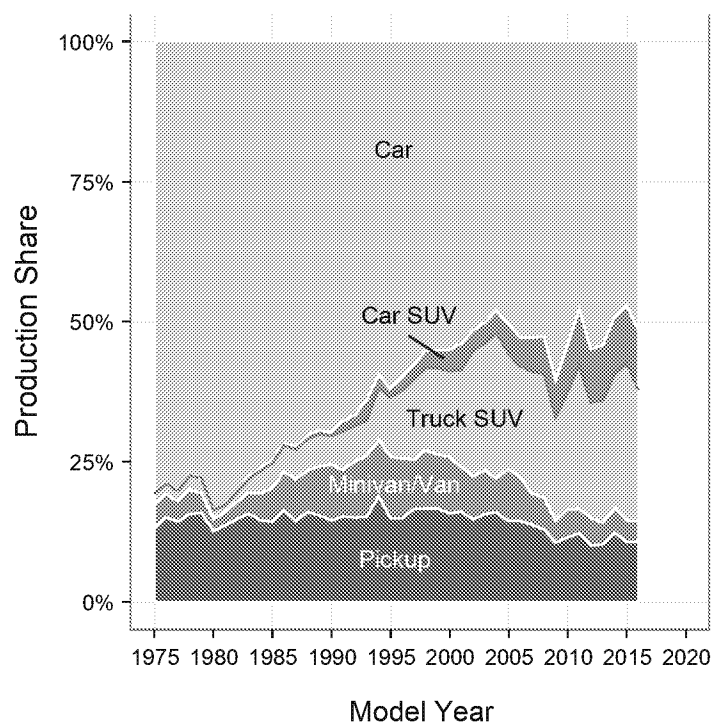
Table 3.1

Vehicle Type Production Share by Model Year

Model Year	Car (non-SUV)	Car SUV	All Car	Truck SUV	Pickup	Minivan/ Van	All Truck
1975	80.6%	0.1%	80.7%	1.7%	13.1%	4.5%	19.3%
1976	78.8%	0.1%	78.9%	1.9%	15.1%	4.1%	21.1%
1977	80.0%	0.1%	80.1%	1.9%	14.3%	3.6%	19.9%
1978	77.3%	0.1%	77.5%	2.5%	15.7%	4.3%	22.5%
1979	77.8%	0.1%	77.9%	2.8%	15.9%	3.5%	22.1%
1980	83.5%	0.0%	83.5%	1.6%	12.7%	2.1%	16.5%
1981	82.7%	0.0%	82.8%	1.3%	13.6%	2.3%	17.2%
1982	80.3%	0.1%	80.5%	1.5%	14.8%	3.2%	19.5%
1983	77.7%	0.3%	78.0%	2.5%	15.8%	3.7%	22.0%
1984	76.1%	0.4%	76.5%	4.1%	14.6%	4.8%	23.5%
1985	74.6%	0.6%	75.2%	4.5%	14.4%	5.9%	24.8%
1986	71.7%	0.4%	72.1%	4.6%	16.5%	6.8%	27.9%
1987	72.2%	0.6%	72.8%	5.2%	14.4%	7.5%	27.2%
1988	70.2%	0.7%	70.9%	5.6%	16.1%	7.4%	29.1%
1989	69.3%	0.7%	70.1%	5.7%	15.4%	8.8%	29.9%
1990	69.8%	0.5%	70.4%	5.1%	14.5%	10.0%	29.6%
1991	67.8%	1.8%	69.6%	6.9%	15.3%	8.2%	30.4%
1992	66.6%	2.0%	68.6%	6.2%	15.1%	10.0%	31.4%
1993	64.0%	3.6%	67.6%	6.3%	15.2%	10.9%	32.4%
1994	59.6%	2.3%	61.9%	9.1%	18.9%	10.0%	38.1%
1995	62.0%	1.5%	63.5%	10.5%	15.0%	11.0%	36.5%
1996	60.0%	2.2%	62.2%	12.2%	14.9%	10.7%	37.8%
1997	57.6%	2.5%	60.1%	14.5%	16.7%	8.8%	39.9%
1998	55.1%	3.1%	58.3%	14.7%	16.7%	10.3%	41.7%
1999	55.1%	3.2%	58.3%	15.4%	16.7%	9.6%	41.7%
2000	55.1%	3.7%	58.8%	15.2%	15.8%	10.2%	41.2%
2001	53.9%	4.8%	58.6%	17.3%	16.1%	7.9%	41.4%
2002	51.5%	3.7%	55.2%	22.3%	14.8%	7.7%	44.8%
2003	50.2%	3.6%	53.9%	22.6%	15.7%	7.8%	46.1%
2004	48.0%	4.1%	52.0%	25.9%	15.9%	6.1%	48.0%
2005	50.5%	5.1%	55.6%	20.6%	14.5%	9.3%	44.4%
2006	52.9%	5.0%	57.9%	19.9%	14.5%	7.7%	42.1%
2007	52.9%	6.0%	58.9%	21.7%	13.8%	5.5%	41.1%
2008	52.7%	6.6%	59.3%	22.1%	12.9%	5.7%	40.7%
2009	60.5%	6.5%	67.0%	18.4%	10.6%	4.0%	33.0%
2010	54.5%	8.2%	62.8%	20.7%	11.5%	5.0%	37.2%
2011	47.8%	10.0%	57.8%	25.5%	12.3%	4.3%	42.2%
2012	55.0%	9.4%	64.4%	20.6%	10.1%	4.9%	35.6%
2013	54.1%	10.0%	64.1%	21.8%	10.4%	3.8%	35.9%
2014	49.2%	10.1%	59.3%	23.9%	12.4%	4.3%	40.7%
2015	47.2%	10.2%	57.4%	28.1%	10.7%	3.9%	42.6%
2016 (prelim)	*51.4%*	*10.7%*	*62.1%*	*23.4%*	*10.8%*	*3.7%*	*37.9%*

The data from Table 3.1 show that car type market share has dropped from around 80% in the MY 1975-1985 timeframe to below 50% today. Pickups accounted for most of the remaining market share in MY 1975-1985. In the late 1980s, both minivans/vans and truck SUVs began to erode car type market share, with truck SUV market share reaching 28% in MY 2015. More recently, car SUVs have become more popular and have increased market share to over 10%. Total SUVs, including both car SUVs and truck SUVs, have increased market share to over 38% in MY 2015. Pickup market share was approximately 15% from MY 1975 through MY 2005, but has declined slightly to approximately 11% in MY 2015.

Table 3.2 shows adjusted fuel economy and CO_2 emissions by model type since 1975. Each of the 5 vehicle types are at or near record fuel economy and CO_2 emissions levels in the final MY 2015 data. The car type achieves the highest preliminary fuel economy value for MY 2015, followed by car SUVs, truck SUVs, minivans/vans, and pickups. Each vehicle type is projected to improve further in the preliminary MY 2016 data, except for minivans/vans which are projected to stay the same. Interestingly, over the 5-year period from MY 2011-2016, the vehicle types that have achieved the largest improvement in CO_2 emissions are those with the lowest absolute fuel economy. Truck SUVs have reduced CO_2 emissions by 56 g/mi since MY 2011 and pickups have reduced CO_2 emissions by 47 g/mi since MY 2011, while the other vehicle types all showed smaller reductions.

Table 3.2

Vehicle Type Adjusted Fuel Economy and CO_2 Emissions by Model Year

Model Year	Car (non- SUV)		Car SUV		Pickup		Truck SUV		Minivan/Van	
	Adj Fuel Economy (MPG)	Adj CO_2 (g/mi)	Adj Fuel Economy (MPG)	Adj CO_2 (g/mi)	Adj Fuel Economy (MPG)	Adj CO_2 (g/mi)	Adj Fuel Economy (MPG)	Adj CO_2 (g/mi)	Adj Fuel Economy (MPG)	Adj CO_2 (g/mi)
1975	13.5	660	11.1	799	11.9	746	11.0	806	11.1	800
1976	14.9	598	10.6	840	12.4	714	11.8	755	11.8	754
1977	15.6	570	12.2	731	13.6	656	12.8	692	12.5	710
1978	16.9	525	11.6	768	13.3	668	12.3	723	12.1	736
1979	17.2	517	14.3	623	13.2	674	10.5	844	11.5	774
1980	20.0	446	14.6	610	16.5	541	13.2	676	14.1	629
1981	21.4	418	14.7	605	17.9	500	14.3	621	14.8	599
1982	22.2	402	19.8	450	18.5	486	14.7	616	14.7	605
1983	22.1	403	20.7	430	18.9	473	15.8	568	15.1	593
1984	22.4	397	19.3	461	18.3	488	16.2	551	16.1	552
1985	23.0	387	20.1	443	18.2	489	16.5	538	16.5	537
1986	23.7	375	18.9	470	18.9	471	17.0	523	17.5	509
1987	23.8	373	19.4	458	19.0	467	17.3	515	17.7	503
1988	24.1	368	19.2	462	18.1	490	17.0	522	17.9	497
1989	23.7	375	19.1	465	17.8	499	16.6	537	17.8	499
1990	23.3	381	18.8	472	17.4	511	16.4	541	17.8	498
1991	23.4	379	18.2	488	18.2	489	16.7	531	17.9	496
1992	23.1	385	17.8	498	17.5	508	16.2	548	17.9	496
1993	23.5	379	17.0	522	17.6	505	16.3	546	18.2	488
1994	23.3	382	18.0	493	17.4	510	16.0	555	17.8	498
1995	23.4	379	17.8	499	16.9	526	16.0	555	18.1	492
1996	23.3	381	18.4	482	17.1	518	16.2	548	18.3	485
1997	23.4	380	19.2	462	16.8	528	16.1	551	18.2	489
1998	23.4	380	18.2	487	17.0	523	16.2	550	18.7	475
1999	23.0	386	18.5	480	16.3	546	16.1	553	18.3	486
2000	22.9	388	17.9	497	16.7	534	16.0	555	18.6	478
2001	23.0	386	18.8	472	16.0	557	16.4	541	18.0	493
2002	23.1	385	19.3	460	15.8	564	16.3	545	18.7	475
2003	23.3	382	19.9	446	16.1	553	16.4	541	19.0	468
2004	23.1	384	20.0	445	15.7	565	16.5	539	19.2	464
2005	23.5	379	20.2	440	15.8	561	16.7	531	19.3	460
2006	23.3	382	20.5	434	16.1	551	17.2	518	19.5	455
2007	24.1	369	20.6	431	16.2	550	17.7	503	19.5	456
2008	24.3	366	21.2	419	16.5	539	18.2	489	19.8	448
2009	25.3	351	22.0	403	16.9	526	19.3	461	20.1	443
2010	26.2	340	23.0	386	16.9	527	19.7	452	20.1	442
2011	26.1	341	23.7	376	17.2	517	19.8	448	21.0	423
2012	27.9	319	23.4	379	17.2	518	20.0	445	21.3	416
2013	28.6	310	24.5	363	17.4	510	20.9	426	21.1	421
2014	28.7	309	24.6	361	18.0	494	21.7	411	21.3	417
2015	29.4	302	25.3	351	18.8	473	22.0	404	21.9	407
2016 (prelim)	29.8	296	25.6	347	19.0	470	22.6	392	21.9	406

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One particular vehicle type trend of interest is associated with small SUVs that are classified as cars if they have 2-wheel drive and as trucks if they have 4-wheel drive and meet other requirements such as minimum angles and clearances. For this analysis, summarized in Table 3.3, we reviewed MY 2000-2016 SUVs with inertia weights of 4000 pounds or less (SUVs with inertia weights of 5000 pounds or more are typically categorized as trucks regardless of whether they are 2-wheel or 4-wheel drive). Note that we have propagated the current car-truck definitions back to previous years in the Trends database in order to maintain the integrity of historical trends (i.e., some vehicles that were defined as trucks in past years are now defined as cars for those same years in the Trends database).

Table 3.3
Car-Truck Classification of SUVs with Inertia Weights of 4000 Pounds or Less

Model Year	Car SUV Production (000)	Truck SUV Production (000)	Total SUV Production (000)	Percent Car SUV	Percent Truck SUV
2000	617	796	1,413	43.7%	56.3%
2001	743	920	1,663	44.7%	55.3%
2002	602	928	1,531	39.4%	60.6%
2003	575	994	1,569	36.6%	63.4%
2004	599	1,116	1,715	34.9%	65.1%
2005	753	867	1,620	46.5%	53.5%
2006	691	758	1,449	47.7%	52.3%
2007	761	843	1,604	47.4%	52.6%
2008	748	799	1,547	48.4%	51.6%
2009	539	575	1,115	48.4%	51.6%
2010	659	854	1,512	43.5%	56.5%
2011	985	1,044	2,029	48.5%	51.5%
2012	1,039	867	1,907	54.5%	45.5%
2013	1,177	1,190	2,367	49.7%	50.3%
2014	1,340	1,533	2,872	46.6%	53.4%
2015	1,427	1,949	3,376	42.3%	57.7%
2016 (prelim)	-	-	-	48.0%	52.0%

Table 3.3 shows that the fraction of SUVs with curb weights less than 4000 pounds that are classified as trucks, using the current car-truck definitions propagated back in time, has been declining somewhat over the last decade, from around 60% in the early 2000s to around 50% in recent years.

Appendix D gives additional data stratified by vehicle type.

C. Vehicle Footprint, Weight, and Horsepower

This sub-section focuses on three key attributes that impact CO_2 emissions and fuel economy. These attributes are footprint, weight, and horsepower. All three attributes are relevant to all light-duty vehicles and were included in the Table 2.1 fleetwide data. Vehicle acceleration is discussed in the following sub-section.

Vehicle footprint is a very important attribute since it is the basis for the current CO_2 emissions and fuel economy standards. Footprint is the product of wheelbase times average track width (or the area defined by where the centers of the tires touch the ground). We provide footprint data beginning with MY 2008, though it is important to highlight that we have higher confidence in the data beginning in MY 2011. Footprint data from MY 2008-2010 were aggregated from various sources, some independent of formal automaker data, and EPA has less confidence in the consistency and precision of this data. Beginning in MY 2011, the first year when both car and truck CAFE standards were based on footprint, automakers began to formally submit reports to EPA with footprint data at the end of the model year, and this formal footprint data is reflected in the final data through MY 2015. EPA projects footprint data for the preliminary MY 2016 fleet based on footprint values for existing models from previous years and footprint values for new vehicle designs available through public sources. With these caveats, Table 2.1 above shows that average fleetwide footprint has hovered around 49 square feet since MY 2008. The MY 2015 footprint is 49.4 square feet, which is a 0.3 square feet decrease relative to MY 2014. The preliminary MY 2016 footprint value is 49.3 square feet, which would be a further reduction of 0.1 square feet. Footprint trends will be a major topic of interest in future Trends reports as we continue to add to the formal data that we began to collect in MY 2011.

Vehicle weight is a fundamental vehicle attribute, both because it can be related to utility functions such as vehicle size and features, and because higher weight, other things being equal, will increase CO_2 emissions and decrease fuel economy. All Trends vehicle weight data are based on inertia weight class. Each inertia weight class represents a range of loaded vehicle weights, or vehicle curb weights plus 300 pounds. Vehicle inertia weight classes are in 250-pound increments for classes below 3000 pounds, while inertia weight classes over 3000 pounds are divided into 500-pound increments. Table 2.1 shows that average fleetwide vehicle weight decreased from nearly 4100 pounds in MY 1976 to 3200 pounds in MY 1981, likely driven by both increasing fuel economy standards (which, at that time, were universal standards, and not based on any type of vehicle attribute) and higher gasoline prices. Average vehicle weight then grew slowly but steadily over the next 23 years (in part because of the increasing truck share), to 4111 pounds in MY 2004. Since 2004, average vehicle weight has stayed fairly constant in the range of 4000 to 4100 pounds, reaching 4127 pounds in MY 2011, an all-time high since the database began in 1975. Average MY 2015 weight was 4035

pounds, a 25 pound increase relative to MY 2014. The preliminary MY 2016 value for weight is 3985 pounds, which if realized would represent a 50 pound decrease compared to MY 2015.

Horsepower (hp) is of interest as a direct measure of vehicle power. In the past, higher power generally increased CO_2 emissions and decreased fuel economy, though this relationship is now less important with turbo and hybrid packages. Horsepower data for all gasoline (including conventional hybrids) and diesel vehicles in the Trends database reflect engine rated horsepower. Average fleetwide horsepower dropped from 137 hp in MY 1975 to 102 hp in MY 1981. Since MY 1981, horsepower values have increased just about every year (again, in part due to the increasing truck share through 2004), and current levels are over twice those of the early 1980s. Average MY 2015 horsepower was 229 hp, a 1 hp decrease relative to the record high in MY 2014. The preliminary value for MY 2016 is also 229 hp.

The following two tables provide data for the three attributes discussed above for the car and truck classes separately (these data are shown for the entire fleet in Table 2.1 above).

Table 3.4.1 shows that car adjusted fuel economy reached its all-time high of 28.6 mpg in MY 2015, which is more than twice the MY 1975 level of 13.5 mpg, and an increase of 0.7 mpg from MY 2014. Car adjusted CO_2 emissions decreased by 8 g/mi to a new all-time low of 310 g/mi. Car weight, horsepower, and footprint were all essentially unchanged from MY 2014 to MY 2015. Car fuel economy is projected to increase by 0.4 mpg in MY 2016 to another record high, while car weight, horsepower, and footprint are projected to increase by 2% or less from MY 2015. The interior volume data shown in Table 3.4.1 is only for car type vehicles, as EPA does not collect interior volume data for car SUVs.

Table 3.4.2 shows that truck adjusted fuel economy was a record high 21.1mpg in MY 2015, which was a 0.7 mpg increase over MY 2014. This increase was tied for the highest truck fuel economy increase in 30 years. Truck weight, horsepower, and footprint were all down slightly from MY 2014 to MY 2015. Truck fuel economy, horsepower, and footprint are all projected to increase in MY 2016, while weight is projected to drop slightly.

Table 3.4.1

Car Adjusted CO₂ Emissions, Adjusted Fuel Economy, and Key Parameters by Model Year

Model Year	Gasoline and Diesel Production (000)	Car Production Share	Adj CO₂ (g/mi)	Adj Fuel Economy (MPG)	Weight (lbs)	HP	Footprint (sq ft)	Interior Volume*
1975	8,247	80.7%	661	13.5	4057	136	-	-
1976	9,734	78.9%	598	14.9	4059	134	-	-
1977	11,318	80.1%	570	15.6	3944	133	-	110
1978	11,191	77.5%	525	16.9	3588	124	-	109
1979	10,810	77.9%	517	17.2	3485	119	-	109
1980	9,444	83.5%	446	20.0	3101	100	-	104
1981	8,734	82.8%	418	21.4	3076	99	-	106
1982	7,832	80.5%	402	22.2	3053	99	-	106
1983	8,035	78.0%	403	22.1	3112	104	-	109
1984	10,730	76.5%	397	22.4	3101	106	-	108
1985	10,879	75.2%	387	23.0	3096	111	-	108
1986	11,074	72.1%	375	23.7	3043	111	-	107
1987	10,826	72.8%	374	23.8	3035	113	-	107
1988	10,845	70.9%	369	24.1	3051	116	-	107
1989	10,126	70.1%	376	23.6	3104	121	-	108
1990	8,875	70.4%	382	23.3	3178	129	-	107
1991	8,747	69.6%	382	23.3	3168	133	-	107
1992	8,350	68.6%	389	22.9	3254	141	-	108
1993	8,929	67.6%	386	23.0	3241	140	-	108
1994	8,747	61.9%	386	23.0	3268	144	-	108
1995	9,616	63.5%	382	23.3	3274	153	-	109
1996	8,177	62.2%	384	23.1	3297	155	-	109
1997	8,695	60.1%	384	23.2	3285	156	-	109
1998	8,425	58.3%	386	23.0	3334	160	-	109
1999	8,865	58.3%	392	22.7	3390	164	-	109
2000	9,742	58.8%	395	22.5	3401	168	-	110
2001	9,148	58.6%	393	22.6	3411	169	-	109
2002	8,903	55.2%	390	22.8	3415	173	-	110
2003	8,496	53.9%	386	23.0	3437	176	-	110
2004	8,176	52.0%	389	22.9	3492	184	-	110
2005	8,839	55.6%	384	23.1	3498	183	-	111
2006	8,744	57.9%	386	23.0	3563	194	-	112
2007	9,001	58.9%	375	23.7	3551	191	-	110
2008	8,243	59.3%	372	23.9	3569	194	45.3	110
2009	6,244	67.0%	356	25.0	3502	186	45.2	110
2010	6,976	62.8%	346	25.7	3536	190	45.4	110
2011	6,949	57.8%	347	25.6	3617	200	46.0	111
2012	8,658	64.4%	328	27.1	3519	192	45.7	111
2013	9,740	64.1%	319	27.9	3543	197	45.9	110
2014	9,205	59.3%	318	27.9	3559	198	46.1	111
2015	9,601	57.4%	310	28.6	3556	197	46.1	111
2016 (prelim)	-	62.1%	305	29.0	3568	201	46.3	112

* Interior volume calculated using "Car" type only and does not include Car SUVs.

Table 3.4.2

Truck Adjusted CO₂ Emissions, Adjusted Fuel Economy, and Key Parameters by Model Year

Model Year	Gasoline and Diesel Production (000)	Truck Production Share	Adj CO₂ (g/mi)	Adj Fuel Economy (MPG)	Weight (lbs)	HP	Footprint (sq ft)
1975	1,977	19.3%	764	11.6	4073	142	-
1976	2,600	21.1%	726	12.2	4155	141	-
1977	2,805	19.9%	669	13.3	4136	147	-
1978	3,257	22.5%	687	12.9	4152	146	-
1979	3,072	22.1%	711	12.5	4257	138	-
1980	1,863	16.5%	565	15.8	3869	121	-
1981	1,821	17.2%	523	17.1	3806	119	-
1982	1,901	19.5%	516	17.4	3813	120	-
1983	2,267	22.0%	504	17.7	3773	118	-
1984	3,289	23.5%	512	17.4	3787	118	-
1985	3,581	24.8%	509	17.5	3803	124	-
1986	4,291	27.9%	489	18.2	3741	123	-
1987	4,039	27.2%	486	18.3	3718	131	-
1988	4,450	29.1%	498	17.8	3850	141	-
1989	4,327	29.9%	506	17.6	3932	146	-
1990	3,740	29.6%	512	17.4	4014	151	-
1991	3,825	30.4%	500	17.8	3961	150	-
1992	3,822	31.4%	512	17.3	4078	155	-
1993	4,281	32.4%	507	17.5	4098	160	-
1994	5,378	38.1%	518	17.2	4149	166	-
1995	5,529	36.5%	524	17.0	4201	168	-
1996	4,967	37.8%	518	17.2	4255	179	-
1997	5,762	39.9%	528	16.8	4394	189	-
1998	6,030	41.7%	521	17.1	4317	188	-
1999	6,350	41.7%	535	16.6	4457	199	-
2000	6,829	41.2%	528	16.8	4421	199	-
2001	6,458	41.4%	538	16.5	4543	212	-
2002	7,211	44.8%	539	16.5	4612	223	-
2003	7,277	46.1%	533	16.7	4655	224	-
2004	7,533	48.0%	538	16.5	4783	240	-
2005	7,053	44.4%	526	16.9	4763	242	-
2006	6,360	42.1%	518	17.2	4758	240	-
2007	6,275	41.1%	512	17.4	4871	254	-
2008	5,656	40.7%	499	17.8	4837	254	54.0
2009	3,071	33.0%	480	18.5	4753	252	54.0
2010	4,141	37.2%	474	18.8	4784	253	53.8
2011	5,069	42.2%	466	19.1	4824	271	54.4
2012	4,790	35.6%	461	19.3	4809	276	54.5
2013	5,458	35.9%	450	19.8	4824	277	54.7
2014	6,307	40.7%	437	20.4	4790	277	55.0
2015	7,138	42.6%	421	21.1	4680	271	53.9
2016 (prelim)	*-*	*37.9%*	*416*	*21.4*	*4668*	*275*	*54.2*

Figure 3.5 includes summary charts showing long-term trends for adjusted CO_2 emissions, adjusted fuel economy, footprint, weight, and horsepower for the five vehicle types discussed above. Most of the long-term trends are similar across the various vehicle types, with the major exception being pickups, for which CO_2 emissions and fuel economy have not reached all-time records in recent years (unlike the other vehicle types) due to considerably greater increases in weight and horsepower relative to the other vehicle types.

Figure 3.5

Adjusted CO₂ Emissions, Adjusted Fuel Economy and Other Key Parameters by Vehicle Type
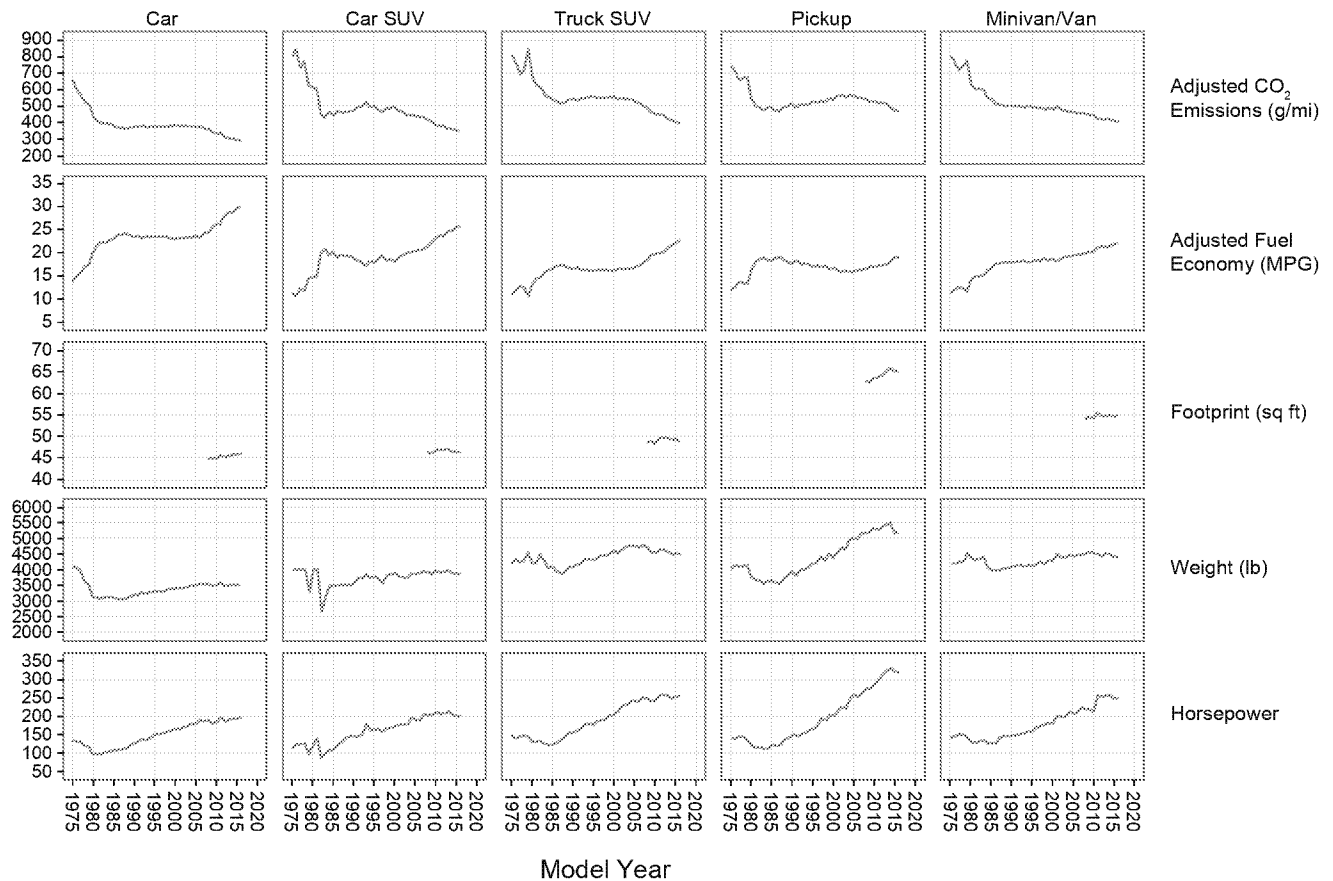
Figure 3.6 shows footprint data for average new vehicles and each of the five vehicle types since MY 2008. The largest changes have occurred within the pickup vehicle type. Pickup footprint is up nearly 4% between MY 2008 and MY 2015, to an average of 65.3 square feet. The average footprint within each of the other four vehicle types has been relatively stable. The average footprint for cars is up about 2% to 46.0 square feet. Truck SUV footprint increased 1.3%, car SUVs increased 0.3%, and minivans/vans increased 0.9%.

The overall new vehicle footprint has also been relatively stable since MY 2008. The overall average is influenced by the trends within each vehicle type, as well as the mix of new vehicles produced. In MY 2015, the market continued a shift towards car SUVs and truck SUVs, and away from cars, pickups, and minivans/vans. The result of this shift, along with the changes within each vehicle type, is that overall industry footprint increased by about 1% between MY 2008 and MY 2015.

Figure 3.6
Footprint by Vehicle Type for MY 2008–2016
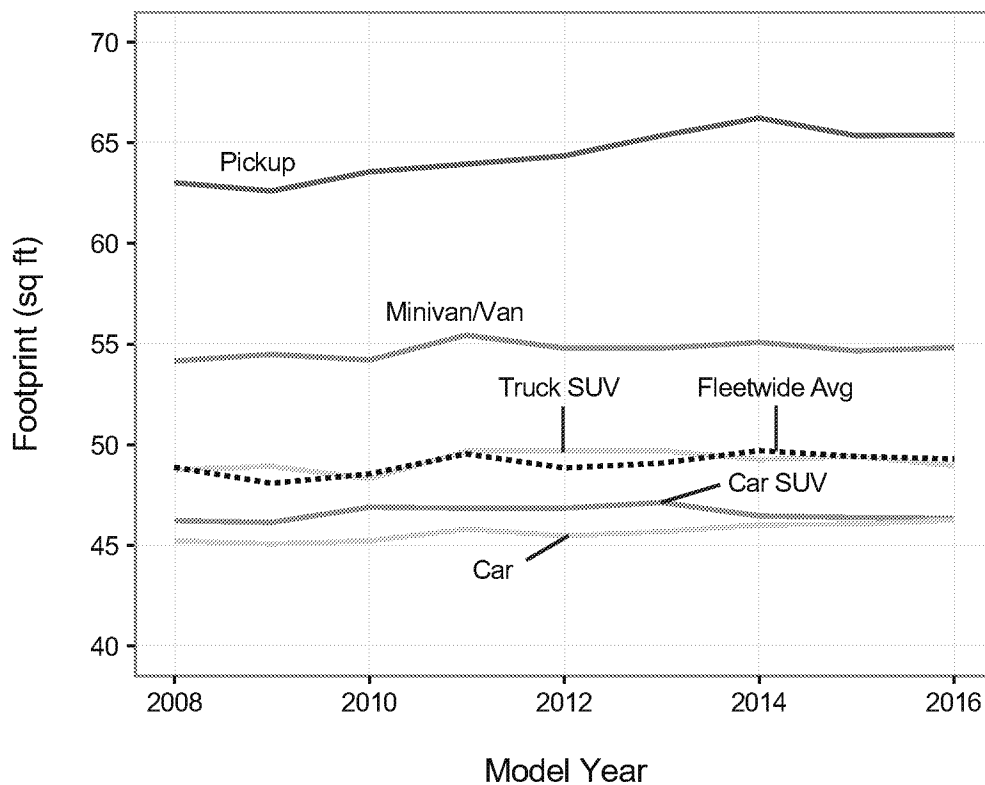
Figure 3.7 shows the annual production share of different inertia weight classes for cars and trucks. This figure again shows the "compression" on the car side that was also discussed with respect to interior volume—in the late 1970s there were significant car sales both in the <2750 pound class as well as in the 5500 pound class (interestingly, there were more 5500 pound cars sold in the late 1970s than there were 5500 pound trucks). Today, both the lightest and heaviest cars have largely disappeared from the market, and over 95% of all cars are in just three inertia weight classes (3000, 3500, and 4000 pounds). Conversely, the heavy end of the truck market has expanded markedly such that 4500 pounds and greater trucks now account for over 75% of the truck market.

Figure 3.7

Car and Truck Production Share by Vehicle Inertia Weight Class
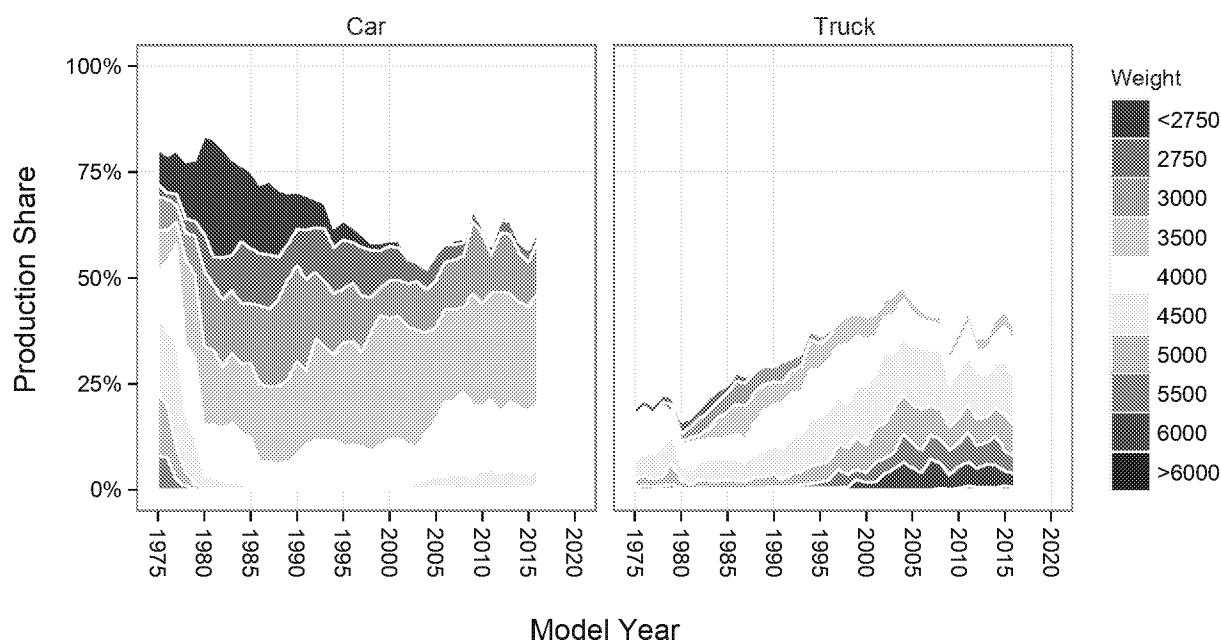
The next three figures, Figures 3.8 through 3.10, address the engineering relationships between efficiency and three key vehicle attributes: footprint, weight, and interior volume (car type only). It is important to emphasize that, in order to best reflect the engineering relationships involved, these figures differ from most of the figures and tables presented so far in four important ways. One, they show *fuel consumption* (the inverse of fuel economy), because fuel consumption represents a linear relationship while fuel economy is non-linear (i.e., a 1 mpg difference at a lower fuel economy represents a greater change in fuel consumption than a 1 mpg difference at a higher fuel economy). The metric used for fuel consumption is gallons per 100 miles, also shown on new vehicle Fuel Economy and Environment Labels. Fuel consumption is an excellent surrogate for CO_2 emissions, as well. Two, Figures 3.8 through 3.10 show *unadjusted, laboratory* values (for fuel consumption), rather than the adjusted values shown primarily in this report, in order to exclude the impact of non-technology factors associated with the adjusted fuel economy values (e.g., changes in

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driving speeds or use of air conditioning over time). Three, there is **no sales weighting** in either the calculations of the individual data points or the regression lines as the purpose of these figures is to illustrate the technical relationships between fuel consumption and key vehicle attributes, independent of market success. The non-hybrid gasoline, diesel, and gasoline hybrid data points in these figures are averages for each integer footprint value and are plotted separately to illustrate the differences between these technologies. The regression lines are based on the non-hybrid gasoline data points only. As would be expected, the hybrid and diesel data points almost always reflect lower fuel consumption than the regression line representing non-hybrid gasoline vehicles. Finally, these figures exclude alternative fuel vehicles.

Figure 3.8 shows unadjusted, laboratory fuel consumption as a function of vehicle footprint for the MY 2015 car and truck fleets. On average, higher footprint values are correlated with greater fuel consumption. Car fuel consumption is more sensitive to footprint (i.e., greater slope for the regression line) than truck fuel consumption, though this relationship is exaggerated somewhat by the fact that the highest footprint cars are low-volume luxury cars with very high fuel consumption. Most cars have footprint values below 55 square feet, and at these footprint levels, the average car has lower fuel consumption than the average truck. For the much smaller number of cars that have footprint values greater than 55 square feet (typically performance or luxury cars), these cars generally have higher fuel consumption than trucks of the same footprint.

Figure 3.8

Unadjusted, Laboratory Fuel Consumption vs. Footprint, Car and Truck, MY 2015, AFVs Excluded
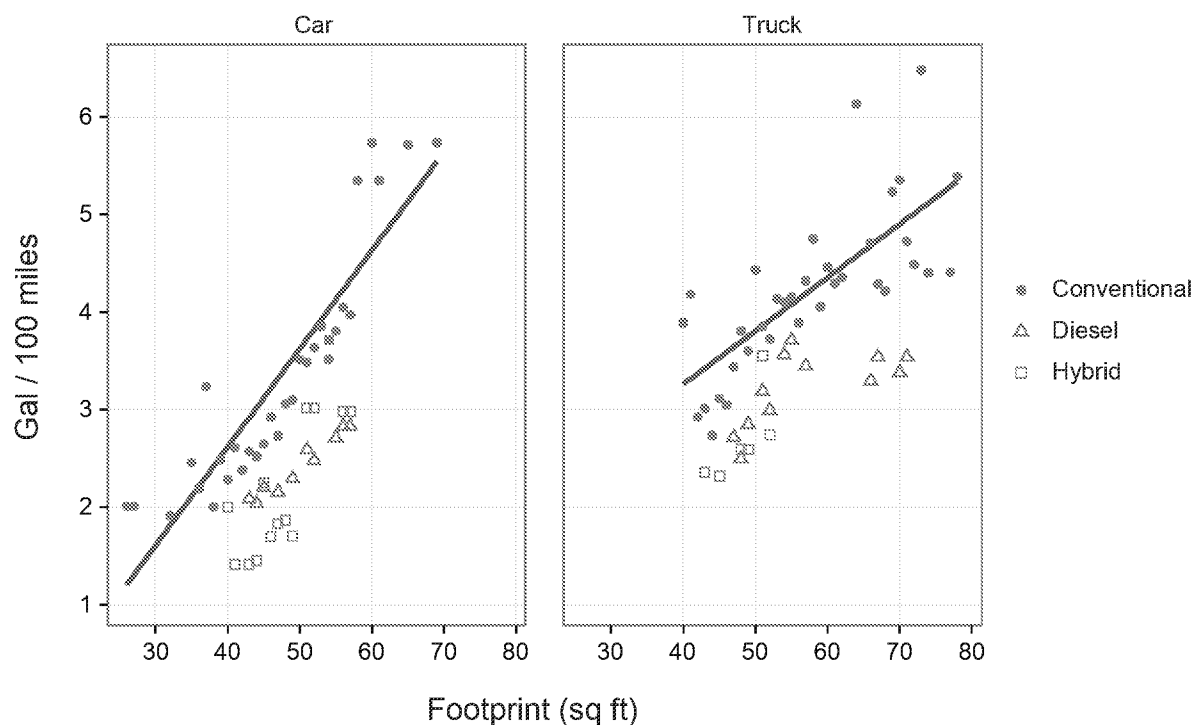
Figure 3.9 shows unadjusted, laboratory fuel consumption as a function of vehicle inertia weight for the MY 1975 and MY 2015 car and truck fleets. On average, fuel consumption increases linearly with vehicle weight, and the regressions are particularly tight for the data points representing non-hybrid gasoline vehicles. In 1975, trucks consistently had higher fuel consumption than cars for a given weight, but in 2015, the differences were much smaller, and at 5000 pounds and above, the average car had higher fuel consumption than the average truck, again likely due to the fact that very heavy cars are typically luxury and/or performance vehicles with high fuel consumption. At a given weight, most cars and trucks have reduced their fuel consumption by about 50% since 1975, with the major exception being the heaviest cars which have achieved more modest reductions in fuel consumption.

Figure 3.9
Unadjusted, Laboratory Fuel Consumption vs. Inertia Weight, Car and Truck, MY 1975 and MY 2015, AFVs Excluded
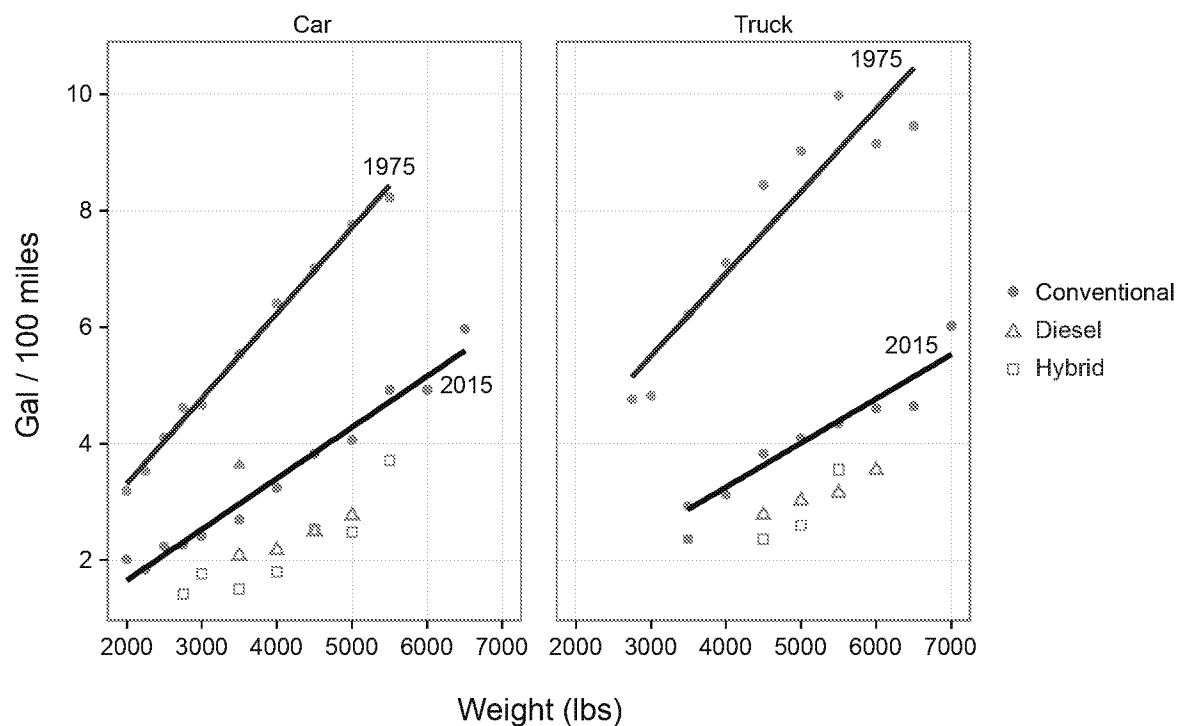
Finally, Figure 3.10 shows unadjusted, laboratory fuel consumption as a function of interior volume for MY 1978 and 2015 for the car type only. This figure excludes two-seater cars, as interior volume data is not reported for two-seaters. The data for MY 1978 is much more scattered than that for MY 2015. The slope of the regression line for non-hybrid gasoline vehicles in 2015 is nearly flat, suggesting that there is no longer much of a relationship between interior volume and fuel consumption within the car type. This MY 2015 data confirms the point made earlier in this section that interior volume is no longer a good attribute for differentiating among vehicles within the car type.

Figure 3.10

Unadjusted, Laboratory Fuel Consumption vs. Car Type Interior Volume, MY 1978 and MY 2015, AFVs Excluded

D. Vehicle Acceleration

Vehicle performance can be evaluated in many ways, including vehicle handling, braking, and acceleration. In the context of this report, acceleration is an important metric because there is a general correlation between how quickly a vehicle can accelerate and fuel economy. The most common vehicle acceleration metric, and one of the most recognized vehicle metrics overall, is the time it takes a vehicle to accelerate from 0-to-60 miles per hour, also called the 0-to-60 time. There are other metrics that are relevant for evaluating vehicle acceleration, including the time to reach 30 miles per hour or the time to travel a quarter mile, but this section is limited to a discussion of 0-to-60 acceleration times. Acceleration times are calculated for most vehicles (obtained from external sources for conventional hybrids and alternative fuel vehicles) since this data is not reported by manufacturers to EPA.

Unlike most of the data presented in this report, 0-to-60 times are based on calculations and are not directly submitted to the EPA by manufacturers. The 0-to-60 metric is a very commonly used automotive metric; however, there is no standard method of measuring 0-to-60 times. Nor, to our knowledge, is there a complete published list of measured vehicle 0-to-60 acceleration times. This report relies on calculated 0-to-60 times based on MacKenzie, 2012, for most vehicles.

Trends in 0-to-60 Times

Since the early 1980s, there has been a clear downward trend in 0-to-60 times. Figure 3.11 shows the average new vehicle 0-to-60 acceleration time from MY 1978 to MY 2016 based on a calculation methodology described below. The average new vehicle in MY 2016 is projected to have a 0-to-60 time of about 8.2 seconds, which is the fastest average 0-to-60 time since the database began in 1975. Average vehicle horsepower has also substantially increased since MY 1982, as shown in Figure 2.3, and clearly at least part of that increase in power has been focused on decreasing acceleration time (some has also been used to support larger, heavier vehicles).

Figure 3.11

Calculated 0-to-60 Acceleration Performance
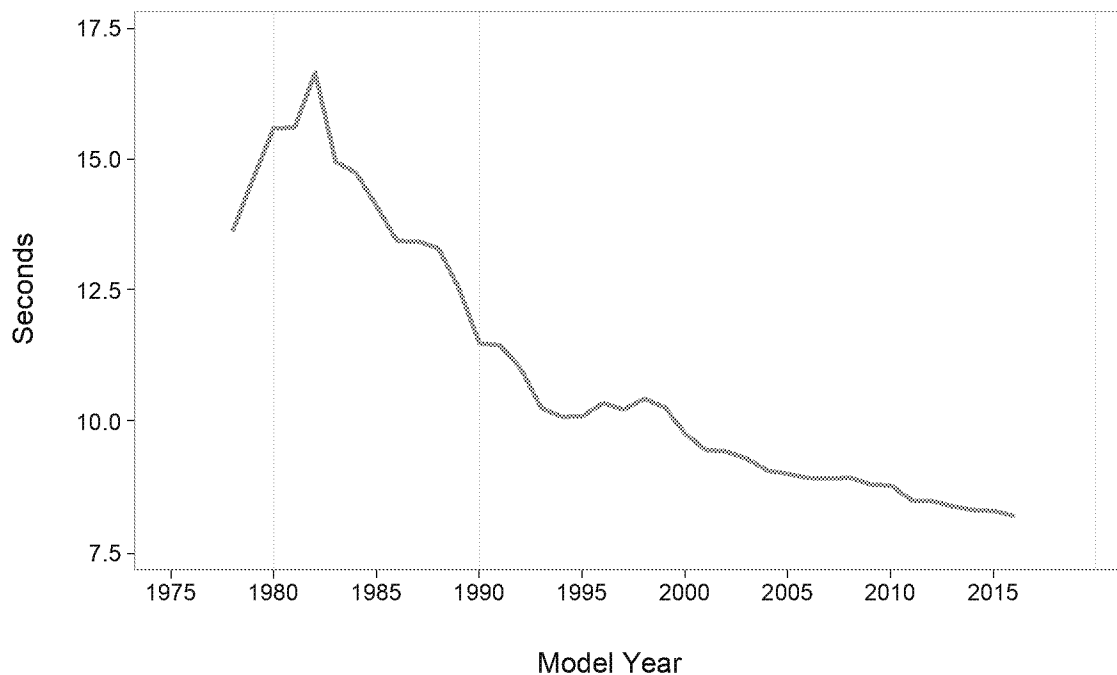
The decreasing long-term trend in 0-to-60 times is consistent across all vehicle types, as shown in Figure 3.12. The trend of decreasing acceleration time appears to be slowing somewhat in recent years for cars, car SUVs, and truck SUVs. The opposite is true for pickup trucks, where calculated 0-to-60 times continue to steadily decrease. Pickups are generally designed to emphasize towing and hauling capabilities, while maintaining adequate driving performance. The continuing decrease in pickup truck 0-to-60 times is likely due to the increasing towing and hauling capacity of pickups, which decreases the calculated 0-to-60 times of pickups.

Vehicle acceleration is determined by many factors, including weight, horsepower, transmission design, engine technologies, and body style. The impacts of these, and other factors, on 0-to-60 times have been evaluated in the literature (MacKenzie, 2012). Many of the same factors that affect acceleration also influence vehicle fuel economy, the result being a general correlation between faster 0-to-60 times and lower fuel economy. All other things equal, a vehicle with more power will likely have faster 0-to-60 acceleration and lower fuel economy. However, there are factors that can improve *both* 0-to-60 acceleration and fuel economy, such as reducing weight.

Acceleration remains an important parameter that will be tracked in this report to evaluate vehicle performance. The 0-to-60 metric is only one of many performance metrics (e.g. stopping distance, skid pad g's, lane change maneuver speed, etc.), but it remains an important parameter that will be tracked in this report due to its strong association with vehicle fuel economy and emissions.

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Figure 3.12

Acceleration Performance by Vehicle Type

Car

Car SUV

Truck SUV

Pickup

Minivan/Van

Seconds

Model Year
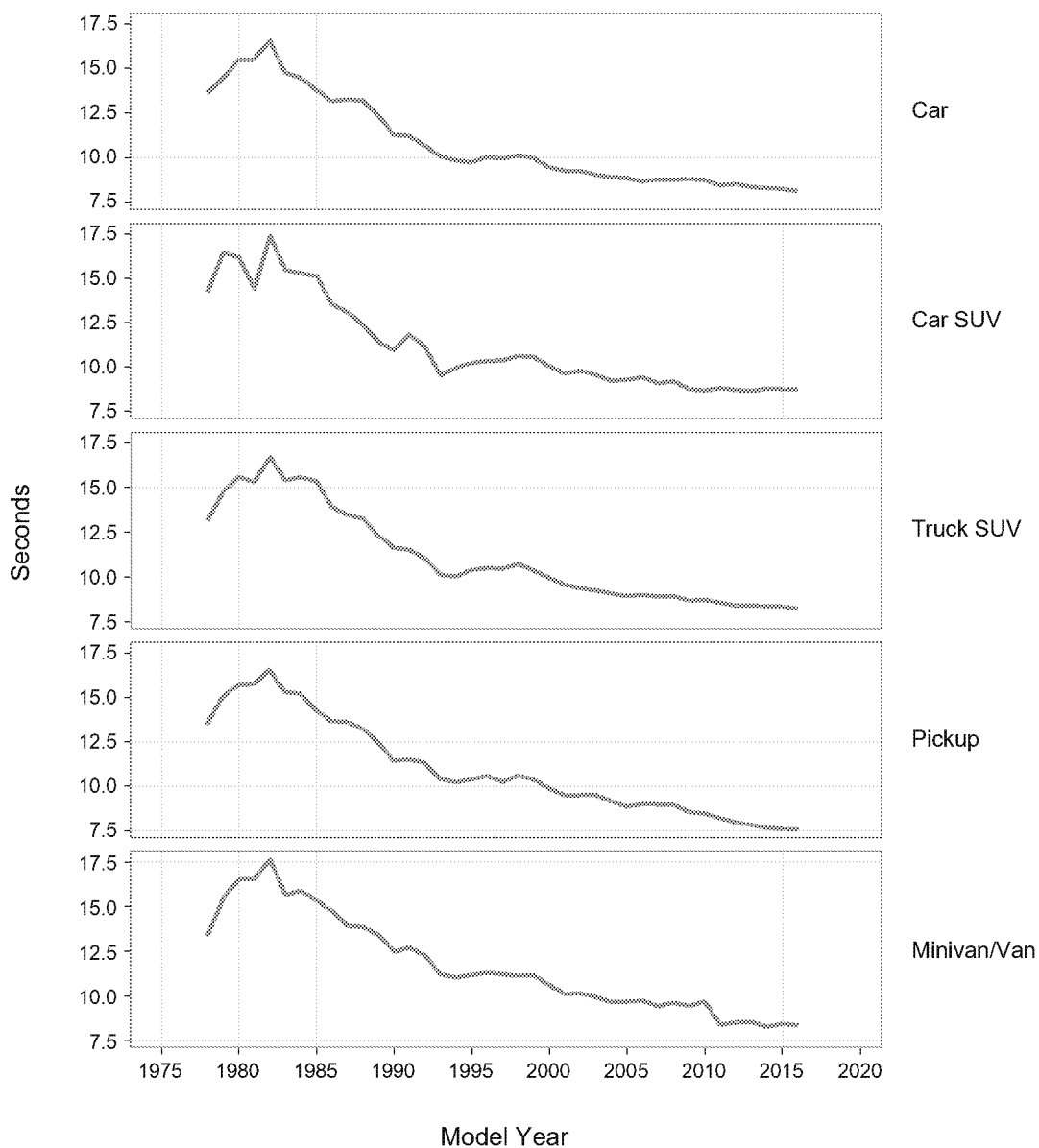
4 Manufacturers and Makes

This section groups vehicles by "manufacturer" and "make." Manufacturer definitions are those used by both EPA and the National Highway Traffic Safety Administration (NHTSA) for purposes of implementation of GHG emissions standards and the corporate average fuel economy (CAFE) program, respectively. Each year, the manufacturer definitions in the historical Trends database are updated, if necessary, to be consistent with the current definitions used for regulatory compliance.

Most of the tables in this section show adjusted CO_2 emissions and fuel economy data which are the best estimates for real world CO_2 emissions and fuel economy performance, but are not comparable to regulatory compliance values. Two tables in this section—Tables 4.4 and 4.5—show unadjusted, laboratory fuel economy and CO_2 emissions values, which form the basis for regulatory compliance values, though they do not reflect various compliance credits, incentives, and flexibilities available to automakers. Adjusted CO_2 values are, on average, about 25% higher than the unadjusted CO_2 values that form the starting point for GHG standards compliance. Adjusted fuel economy values are about 20% lower, on average, than unadjusted fuel economy values (note that these values differ because CO_2 emissions are proportional to fuel consumption, both expressed in units of "per mile," while fuel economy is the mathematical inverse of fuel consumption) that form the starting point for CAFE compliance.

All 2011 and later values in this section include data from alternative fuel vehicles based on the mpge fuel economy metric and the tailpipe CO_2 emissions metric. Section 4.D shows that the impact of including alternative fuel vehicles is measureable for some manufacturers, but zero or negligible for others. Section 7 contains additional data for alternative fuel vehicles.

Information about compliance with EPA's GHG emissions standards, including EPA's Manufacturer Performance Report for the 2015 Model Year, is available at www.epa.gov/regulations-emissions-vehicles-and-engines/ghg-emission-standards-light-duty-vehicles-manufacturer. NHTSA's "Summary of Fuel Economy Performance," summarizing automaker compliance with fuel economy standards, is available at www.nhtsa.gov/Laws-&-Regulations/CAFE---Fuel-Economy.

A. MANUFACTURER AND MAKE DEFINITIONS

Table 4.1 lists the 13 manufacturers which had production of 150,000 or more vehicles in MY 2014 or MY 2015, and which cumulatively accounted for approximately 98% of total industry-wide production. There are no changes to the list of manufacturers in Table 4.1 included in this year's report. Make is typically included in the model name and is generally equivalent to the "brand" of the vehicle. Table 4.1 also lists the 28 makes for which data are shown in subsequent tables. The only change in the list of makes this year is for Alfa Romeo, which was reintroduced into the U.S. market. The production threshold for makes to be included in Tables 4.2 through 4.5 is 40,000 vehicles in MY 2014 or MY 2015.

Table 4.1

Manufacturers and Makes for MY 2014–2016

Manufacturer	Makes Above Threshold	Makes Below Threshold
General Motors	Chevrolet, Cadillac, Buick, GMC	
Toyota	Toyota, Lexus, Scion	
Ford	Ford, Lincoln	Roush, Shelby
Honda	Honda, Acura	
Fiat-Chrysler	Chrysler, Dodge, Jeep, Ram, Fiat	Ferrari, Maserati, Alfa Romeo
Nissan	Nissan, Infiniti	
Hyundai	Hyundai	
Kia	Kia	
BMW	BMW, Mini	Rolls Royce
Volkswagen	Volkswagen, Audi, Porsche	Lamborghini, Bentley, Bugatti
Subaru	Subaru	
Mercedes	Mercedes	Smart, Maybach
Mazda	Mazda	
Others*		

*Note: Other manufacturers below the manufacturer threshold are Mitsubishi, Volvo, Rover, Suzuki, Jaguar Land Rover, Aston Martin, Lotus, BYD, McLaren, Quantum (which only produces one dual fuel CNG vehicle), and Tesla.

It is important to note that when a manufacturer or make grouping is modified to reflect a change in the industry's current financial structure, EPA makes the same adjustment to the entire historical database. This maintains consistent manufacturer and make definitions over time, which allows a better identification of long-term trends. On the other hand, this means that the current database does not necessarily reflect the actual corporate arrangements of the past. For example, the 2016 database no longer accounts for the fact that Chrysler was combined with Mercedes/Daimler for several years, and includes Chrysler in the Fiat-Chrysler manufacturer grouping for the entire database even though these other companies have been financially connected for only a few years.

Automakers submit vehicle production data, rather than vehicle sales data, in formal end-of-year CAFE and GHG emissions compliance reports to EPA. These vehicle production data are tabulated on a model year basis. Accordingly, the vehicle production data presented in this report often differ from similar data reported by press sources, which typically are based on vehicle sales data reported on a calendar basis. In years past, manufacturers typically used a more consistent approach for model year designations, i.e., from fall of one year to the fall of the following year. More recently, however, many manufacturers have used a more flexible approach, and it is not uncommon to see a new or redesigned model introduced with a new model year designation in the spring or summer, rather than the fall. This means that a model year for an individual vehicle can be either shortened or lengthened. Accordingly, year-to-year comparisons can be affected by these model year anomalies, though the overall trends even out over a multi-year period.

B. MANUFACTURER AND MAKE FUEL ECONOMY AND CO_2 EMISSIONS

Tables 4.2 through 4.5 provide comparative manufacturer- and make-specific data for fuel economy and CO_2 emissions for the three years from MY 2014-2016. Data are shown for cars only, trucks only, and cars and trucks combined. By including data from both MY 2014 and 2015, with formal end-of-year data for both years, it is possible to identify meaningful changes from year-to-year. Because of the uncertainty associated with the preliminary MY 2016 projections, changes from MY 2015 to MY 2016 are less meaningful.

In this section, tables are presented with both adjusted (Tables 4.2 and 4.3) and unadjusted, laboratory (Tables 4.4 and 4.5) data. Tables 4.2 and 4.3 provide adjusted data for fuel economy and CO_2 emissions, and therefore are consistent with tables presented earlier in the report. The data in these tables are very similar to the data used to generate the EPA/DOT Fuel Economy and Environment Labels and represent EPA's best estimate of nationwide real world fuel consumption and CO_2 emissions.

Tables 4.2 and 4.3 show rows with adjusted fuel economy and CO_2 emissions data for 12 manufacturers and 25 makes.

In 2016, the Department of Justice, on behalf of EPA, alleged violations of the Clean Air Act by Volkswagen AG, Audi AG, Volkswagen Group of America, Inc., Volkswagen Group of America Chattanooga Operations, LLC, Porsche AG, and Porsche Cars North America, Inc. The U.S. complaint alleges that certain MY 2009-2016 diesel vehicles are equipped with defeat devices in the form of computer software designed to cheat on federal emissions tests, and that during normal vehicle operation and use, the cars emit levels of oxides of nitrogen (NOx) significantly in excess of the EPA compliant levels. For more information on actions to resolve violations, see www.epa.gov/vw. Oxides of nitrogen emissions are not directly related to tailpipe CO_2 emissions or fuel economy. In this report, EPA uses the CO_2 emissions and fuel economy data from the initial certification of these vehicles. Should the investigation and corrective actions yield different CO_2 and fuel economy data, the revised data will be used in future reports. Because Volkswagen diesels account for less than 1% of industry production, updates to the emissions rates, whether they are higher or lower, will not change the broader trends characterized in this report.

Of the 12 manufacturers shown in the body of Table 4.2, 9 manufacturers increased adjusted fuel economy (combined cars and trucks) from MY 2014 to MY 2015. Mazda had the highest adjusted fuel economy in MY 2015 of 29.6 mpg. Four manufacturers were closely grouped behind Mazda — Honda, Nissan, Subaru, and Hyundai — with adjusted fuel economy values between 28.9 and 27.8 mpg. Fiat-Chrysler had the lowest adjusted fuel economy of 21.8 mpg, followed by General Motors and Ford. Honda achieved the largest increase in adjusted fuel economy from MY 2014-2015 of 1.6 mpg, followed by Nissan at 1.3 mpg.

Three manufacturers had lower adjusted fuel economy values in MY 2015. GM had the largest decrease in overall fuel economy at 0.5 mpg, followed by Toyota at 0.4 mpg and BMW at 0.1 mpg. GM's car fuel economy was flat and truck fuel economy improved between MY 2014 and MY 2015, however a significant increase in the percentage of truck production (almost 11 percentage points) led to an overall decrease in average fuel economy. Toyota also improved truck fuel economy in MY 2015, but a decrease in car fuel economy and a 7 percentage point increase in truck share led to an overall decrease. BMW's small decrease in fuel economy occurred due to very small decreases in both car and truck fuel economy. For MY 2015 cars only, Mazda and Honda were the manufacturers with the highest adjusted fuel economy values of 32.1 and 31.6 mpg, respectively, while Fiat-Chrysler and Mercedes reported the lowest adjusted car fuel economy of 25.6 mpg. For MY 2015 trucks only, Subaru had the highest adjusted fuel economy of 28.2 mpg.

Table 4.2

Adjusted Fuel Economy (MPG) by Manufacturer and Make for MY 2014–2016*

Manufacturer	Make	Final MY 2014			Final MY 2015			Preliminary MY 2016		
		Car	Truck	Car and Truck	Car	Truck	Car and Truck	Car	Truck	Car and Truck
Mazda	All	31.8	24.5	29.4	32.1	24.7	29.6	32.3	26.7	30.7
Honda	Honda	30.8	23.8	27.8	32.2	25.2	29.4	32.6	24.9	29.3
Honda	Acura	25.5	22.9	23.9	27.0	23.0	25.1	27.7	22.5	25.1
Honda	All	30.4	23.7	27.3	31.6	24.9	28.9	31.9	24.5	28.7
Subaru	All	28.2	27.5	27.6	28.9	28.2	28.4	29.6	28.3	28.7
Nissan	Nissan	31.0	21.4	27.6	32.3	23.0	29.1	32.0	24.5	30.1
Nissan	Infiniti	23.4	20.4	21.8	22.9	20.8	21.8	22.6	20.9	21.9
Nissan	All	30.4	21.3	27.0	31.5	22.6	28.3	31.4	24.0	29.5
Hyundai	All	28.1	21.5	27.5	28.4	21.5	27.8	29.3	22.6	28.9
Kia	All	26.2	21.4	25.9	26.8	21.6	26.3	27.7	21.4	26.8
BMW	BMW	27.3	22.9	26.0	27.0	22.8	25.8	26.7	22.2	25.5
BMW	Mini	29.3	-	29.3	29.8	-	29.8	29.3	-	29.3
BMW	All	27.5	22.9	26.4	27.4	22.8	26.3	27.2	22.2	26.0
Toyota	Toyota	32.2	19.6	25.9	32.3	20.5	25.6	32.7	20.3	25.6
Toyota	Lexus	25.2	19.2	23.6	24.4	20.7	23.1	25.7	21.6	24.5
Toyota	Scion	27.0	-	27.0	26.4	-	26.4	32.0	-	32.0
Toyota	All	30.8	19.6	25.6	30.3	20.5	25.2	31.1	20.4	25.6
Mercedes	Mercedes	24.5	19.3	22.9	25.6	20.4	23.5	26.1	21.4	24.8
Mercedes	All	24.8	19.3	23.2	25.6	20.4	23.5	26.1	21.4	24.8
Ford	Ford	27.5	19.1	22.8	27.3	20.1	23.0	28.1	20.3	23.5
Ford	Lincoln	24.8	17.8	21.9	25.0	19.7	22.3	24.2	19.5	21.8
Ford	All	27.4	19.1	22.8	27.2	20.1	23.0	27.8	20.3	23.4
GM	Chevrolet	27.2	19.4	23.6	27.3	19.9	23.1	28.7	19.7	24.9
GM	GMC	24.3	19.1	19.9	24.4	19.4	20.1	23.9	19.3	20.3
GM	Buick	25.5	20.8	23.5	25.7	21.2	23.7	27.0	21.6	24.9
GM	Cadillac	22.0	15.3	21.2	21.2	17.5	19.9	22.7	17.7	21.8
GM	All	26.3	19.3	22.8	26.3	19.7	22.3	27.5	19.7	24.0
Fiat-Chrysler	Jeep	25.1	20.3	21.1	25.6	20.6	21.4	24.9	21.5	22.1
Fiat-Chrysler	Dodge	23.0	20.6	21.7	23.8	20.7	22.1	23.6	20.8	22.5
Fiat-Chrysler	Chrysler	23.6	20.9	22.1	27.1	20.8	25.2	26.5	20.9	25.3
Fiat-Chrysler	Ram	-	17.4	17.4	24.9	18.5	18.5	-	18.8	18.8
Fiat-Chrysler	Fiat	31.1	-	31.1	35.0	-	35.0	28.3	-	28.3
Fiat-Chrysler	All	23.8	19.6	20.8	25.6	20.2	21.8	24.9	20.5	22.2
Other	All	30.5	20.9	25.0	31.7	22.0	27.0	42.0	26.3	32.7
All	All	27.9	20.4	24.3	28.6	21.1	24.8	29.0	21.4	25.6

* Note: Volkswagen is not included in this table due to an ongoing investigation. Based on initial certification data, Volkswagen values for car and truck combined are 26.2 mpg for MY 2014, 26.8 mpg for MY 2015, and 27.3 mpg for preliminary MY 2016. Volkswagen data are included in industry-wide or "All" values. Should the investigation and corrective actions yield different CO_2 and fuel economy data, the revised data will be used in future reports.

In terms of the makes shown in Table 4.2, Fiat achieved the highest combined car and truck fuel economy in MY 2014, of 35.0 mpg, followed by VW and Mini.

Preliminary projections suggest that 10 of the 12 manufacturers shown will improve adjusted fuel economy further in MY 2016, though EPA will not have final data for MY 2016 until next year's report.

Table 4.3 shows manufacturer-specific values for adjusted CO_2 emissions for the same manufacturers, makes and model years as shown in Table 4.2 for adjusted fuel economy. Of the 12 manufacturers shown, 9 manufacturers decreased adjusted CO_2 emissions from MY 2014 to MY 2015. Manufacturer rankings for CO_2 emissions are generally similar to those for fuel economy, though there can be some differences due to diesel vehicle production share (since diesel has a higher carbon content per gallon than gasoline). Of the 12 manufacturers shown in Table 4.3, Mazda had the lowest adjusted CO_2 emissions in MY 2015 of 300 g/mi, and Fiat-Chrysler had the highest adjusted CO_2 emissions of 407 g/mi, however Fiat-Chrysler also achieved the biggest reduction in CO2 emissions, at 21 g/mi. Honda and Nissan achieved the next biggest reductions of 18 and 17 g/mi, respectively. Preliminary values suggest that 10 of the 12 manufacturers could reduce CO_2 emissions in MY 2016. The make rankings for adjusted CO_2 emissions in Table 4.3 are also similar to those for adjusted fuel economy in Table 4.2.

Table 4.3

Adjusted CO$_2$ Emissions (g/mi) by Manufacturer and Make for MY 2014–2016*

Manufacturer	Make	Final MY 2014			Final MY 2015			*Preliminary MY 2016*		
		Car	Truck	Car and Truck	Car	Truck	Car and Truck	*Car*	*Truck*	*Car and Truck*
Mazda	All	280	363	302	277	360	300	*275*	*333*	*290*
Honda	Honda	288	373	320	276	352	302	*272*	*357*	*304*
Honda	Acura	349	388	372	329	387	354	*321*	*395*	*353*
Honda	All	293	375	326	281	357	308	*278*	*363*	*310*
Nissan	Nissan	286	415	321	273	387	303	*274*	*363*	*292*
Nissan	Infiniti	380	436	407	388	428	407	*394*	*426*	*405*
Nissan	All	292	418	329	280	393	312	*280*	*370*	*299*
Subaru	All	315	323	321	308	315	313	*301*	*314*	*310*
Hyundai	All	316	414	323	313	413	320	*303*	*393*	*308*
Kia	All	339	415	343	332	411	338	*320*	*415*	*332*
BMW	BMW	326	391	342	328	396	344	*331*	*404*	*348*
BMW	Mini	303	-	303	298	-	298	*303*	*-*	*303*
BMW	All	323	391	338	323	396	338	*326*	*404*	*342*
Toyota	Toyota	276	453	343	275	434	347	*272*	*438*	*347*
Toyota	Lexus	352	463	377	364	430	385	*345*	*412*	*362*
Toyota	Scion	330	-	330	337	-	337	*278*	*-*	*278*
Toyota	All	289	453	347	294	434	353	*285*	*436*	*347*
Mercedes	Mercedes	363	467	390	346	440	379	*338*	*423*	*359*
Mercedes	All	358	467	385	346	440	379	*338*	*423*	*359*
Ford	Ford	322	465	389	324	442	386	*315*	*438*	*378*
Ford	Lincoln	358	500	406	356	451	399	*367*	*455*	*407*
Ford	All	324	466	389	326	442	387	*318*	*439*	*379*
GM	Chevrolet	325	459	376	324	447	384	*309*	*452*	*356*
GM	GMC	366	464	447	364	459	443	*372*	*461*	*439*
GM	Buick	349	428	378	346	419	375	*329*	*412*	*356*
GM	Cadillac	403	581	418	419	508	446	*391*	*501*	*407*
GM	All	337	460	389	337	451	398	*323*	*452*	*371*
Fiat-Chrysler	Jeep	354	438	421	348	431	416	*357*	*414*	*402*
Fiat-Chrysler	Dodge	387	431	409	374	430	403	*377*	*427*	*395*
Fiat-Chrysler	Chrysler	377	425	403	328	426	353	*335*	*425*	*352*
Fiat-Chrysler	Ram	-	510	510	357	481	480	*-*	*479*	*479*
Fiat-Chrysler	Fiat	279	-	279	240	-	240	*309*	*-*	*309*
Fiat-Chrysler	All	373	452	428	346	440	407	*356*	*436*	*402*
Other	All	275	425	347	268	404	322	*165*	*318*	*237*
All	All	318	437	366	310	421	358	*305*	*416*	*347*

* Note: Volkswagen is not included in this table due to an ongoing investigation. Based on initial certification data, Volkswagen values for car and truck combined are 347 g/mi CO$_2$ for MY 2014, 336 g/mi for MY 2015, and 325 g/mi for preliminary MY 2016. Volkswagen data are included in industry-wide or "All" values. Should the investigation and corrective actions yield different CO$_2$ and fuel economy data, the revised data will be used in future reports.

Tables 4.4 and 4.5 provide <u>unadjusted, laboratory</u> data for both fuel economy and CO_2 emissions for MY 2014-2016 for manufacturers and makes. Unadjusted, laboratory data is particularly relevant in a manufacturer-specific context because it is the foundation for EPA CO_2 emissions and NHTSA CAFE regulatory compliance. It also provides a basis for comparing long-term trends from the perspective of vehicle design only, apart from the factors that affect real world performance that can change over time (i.e., driving behavior such as acceleration rates or the use of air conditioning).

In general, manufacturer rankings based on the unadjusted, laboratory fuel economy and CO_2 values in Tables 4.4 and 4.5 are very similar to those for the adjusted values in Tables 4.2 and 4.3. Adjusted CO2 values are, on average, about 25% higher than the unadjusted, laboratory CO_2 values that form the starting point for GHG standards compliance, and adjusted fuel economy values are about 20% lower, on average, than unadjusted fuel economy values that form the starting point for CAFE standards compliance.

Table 4.4

Unadjusted, Laboratory Fuel Economy (MPG) by Manufacturer and Make for MY 2014–2016*

| Manufacturer	Make	Final MY 2014			Final MY 2015			Preliminary MY 2016		
		Car	Truck	Car and Truck	Car	Truck	Car and Truck	Car	Truck	Car and Truck
Mazda	All	41.0	31.4	37.9	41.4	31.6	38.1	*41.7*	*34.4*	*39.6*
Honda	Honda	39.7	30.0	35.4	41.8	32.0	37.8	*42.3*	*31.7*	*37.7*
Honda	Acura	32.0	28.7	29.9	34.7	28.8	31.8	*35.5*	*28.9*	*32.2*
Honda	All	39.0	29.8	34.7	41.0	31.5	37.0	*41.4*	*31.2*	*36.9*
Subaru	All	36.1	35.4	35.5	37.0	36.4	36.5	*38.0*	*36.4*	*36.9*
Nissan	Nissan	40.2	27.1	35.5	41.9	29.5	37.7	*42.2*	*31.4*	*39.4*
Nissan	Infiniti	29.3	25.6	27.4	28.6	26.6	27.6	*28.6*	*26.8*	*27.9*
Nissan	All	39.3	26.9	34.6	40.7	29.0	36.5	*41.3*	*30.9*	*38.5*
Hyundai	All	35.8	27.3	35.1	36.0	27.5	35.3	*37.4*	*29.1*	*36.8*
Kia	All	33.4	26.9	33.0	34.0	27.2	33.4	*35.4*	*26.9*	*34.0*
BMW	BMW	34.3	28.7	32.7	33.9	28.5	32.4	*33.7*	*28.1*	*32.1*
BMW	Mini	37.9	-	37.9	38.5	-	38.5	*37.7*	*-*	*37.7*
BMW	All	34.7	28.7	33.2	34.6	28.5	33.2	*34.3*	*28.1*	*32.9*
Toyota	Toyota	41.9	24.8	33.2	42.2	25.9	32.8	*42.6*	*25.7*	*32.8*
Toyota	Lexus	32.1	24.0	29.9	31.0	26.0	29.3	*32.6*	*27.2*	*31.1*
Toyota	Scion	34.6	-	34.6	33.7	-	33.7	*41.5*	*-*	*41.5*
Toyota	All	39.9	24.7	32.8	39.2	25.9	32.2	*40.3*	*25.8*	*32.8*
Mercedes	Mercedes	30.8	24.5	28.9	32.5	25.9	29.8	*33.4*	*27.4*	*31.6*
Mercedes	All	31.2	24.5	29.2	32.5	25.9	29.8	*33.4*	*27.4*	*31.6*
Ford	Ford	35.0	23.8	28.7	34.5	25.2	28.9	*35.8*	*25.4*	*29.6*
Ford	Lincoln	31.9	22.1	27.8	32.8	25.0	28.8	*31.0*	*24.5*	*27.7*
Ford	All	34.8	23.8	28.7	34.4	25.2	28.9	*35.4*	*25.4*	*29.5*
GM	Chevrolet	34.6	24.1	29.6	34.7	24.7	29.0	*36.6*	*24.6*	*31.5*
GM	GMC	31.0	23.8	24.9	31.1	24.1	25.0	*30.0*	*24.0*	*25.3*
GM	Buick	32.1	26.1	29.7	32.6	27.0	30.1	*34.9*	*27.4*	*32.0*
GM	Cadillac	27.4	19.9	26.6	26.4	21.6	24.8	*28.4*	*21.9*	*27.2*
GM	All	33.3	24.1	28.6	33.3	24.6	28.0	*34.9*	*24.6*	*30.2*
Fiat-Chrysler	Jeep	31.8	25.4	26.6	32.5	25.9	26.9	*31.7*	*27.1*	*28.0*
Fiat-Chrysler	Dodge	28.5	25.6	27.0	29.5	25.6	27.4	*29.2*	*25.9*	*27.9*
Fiat-Chrysler	Chrysler	29.2	25.9	27.4	33.9	25.8	31.5	*33.1*	*25.9*	*31.5*
Fiat-Chrysler	Ram	-	21.6	21.6	31.5	22.9	23.0	*-*	*23.4*	*23.4*
Fiat-Chrysler	Fiat	40.1	-	40.1	45.7	-	45.7	*36.1*	*-*	*36.1*
Fiat-Chrysler	All	29.8	24.5	25.9	32.1	25.2	27.3	*31.2*	*25.7*	*27.7*
Other	All	38.9	26.3	31.6	40.7	27.8	34.3	*53.7*	*33.7*	*41.9*
All	All	35.6	25.5	30.7	36.5	26.5	31.4	*37.1*	*27.0*	*32.5*

* Note: Volkswagen is not included in this table due to an ongoing investigation. Based on initial certification data, Volkswagen values for car and truck combined are 32.7 mpg for MY 2014, 33.8 mpg for MY 2015, and 34.4 mpg for preliminary MY 2016. Volkswagen data are included in industry-wide or "All" values. Should the investigation and corrective actions yield different CO_2 and fuel economy data, the revised data will be used in future reports.

Table 4.5
Unadjusted, Laboratory CO$_2$ Emissions (g/mi) by Manufacturer and Make for MY 2014–2016*

Manufacturer	Make	Final MY 2014			Final MY 2015			Preliminary MY 2016		
		Car	Truck	Car and Truck	Car	Truck	Car and Truck	Car	Truck	Car and Truck
Mazda	All	217	283	234	215	282	233	*213*	*259*	*224*
Honda	Honda	224	296	251	213	278	235	*210*	*280*	*236*
Honda	Acura	278	310	297	256	309	279	*251*	*308*	*276*
Honda	All	228	298	256	217	282	240	*215*	*284*	*241*
Nissan	Nissan	220	328	250	211	302	235	*208*	*283*	*223*
Nissan	Infiniti	303	347	324	311	334	322	*311*	*332*	*319*
Nissan	All	226	331	257	217	306	242	*213*	*288*	*229*
Subaru	All	246	251	250	240	244	243	*234*	*244*	*241*
Hyundai	All	248	325	254	247	323	252	*238*	*306*	*241*
Kia	All	266	330	269	261	327	266	*251*	*331*	*261*
BMW	BMW	259	311	272	261	315	274	*263*	*320*	*277*
BMW	Mini	234	-	234	231	-	231	*235*	*-*	*235*
BMW	All	256	311	268	256	315	268	*258*	*320*	*271*
Toyota	Toyota	212	359	268	211	344	271	*209*	*346*	*271*
Toyota	Lexus	277	370	298	286	342	304	*272*	*326*	*286*
Toyota	Scion	257	-	257	264	-	264	*214*	*-*	*214*
Toyota	All	223	360	271	227	343	276	*220*	*344*	*271*
Mercedes	Mercedes	289	370	309	273	347	299	*265*	*331*	*282*
Mercedes	All	285	370	306	273	347	299	*265*	*331*	*282*
Ford	Ford	254	373	309	257	353	307	*248*	*349*	*300*
Ford	Lincoln	278	402	319	271	356	309	*287*	*363*	*321*
Ford	All	255	374	309	257	353	307	*250*	*350*	*301*
GM	Chevrolet	256	369	299	256	359	306	*243*	*362*	*282*
GM	GMC	287	373	358	286	369	355	*296*	*371*	*352*
GM	Buick	277	340	300	273	329	295	*255*	*324*	*278*
GM	Cadillac	324	446	334	337	411	359	*313*	*406*	*327*
GM	All	266	369	310	266	362	317	*254*	*362*	*294*
Fiat-Chrysler	Jeep	279	349	335	273	343	330	*280*	*328*	*317*
Fiat-Chrysler	Dodge	312	347	330	301	346	325	*304*	*344*	*318*
Fiat-Chrysler	Chrysler	304	343	325	262	344	283	*268*	*343*	*282*
Fiat-Chrysler	Ram	-	412	412	282	388	387	*-*	*386*	*386*
Fiat-Chrysler	Fiat	217	-	217	185	-	185	*243*	*-*	*243*
Fiat-Chrysler	All	298	363	343	276	352	325	*285*	*348*	*321*
Other	All	216	338	274	209	320	253	*130*	*249*	*187*
All	All	250	348	290	243	335	282	*238*	*330*	*273*

* Note: Volkswagen is not included in this table due to an ongoing investigation. Based on initial certification data, Volkswagen values for car and truck combined are 278 g/mi CO$_2$ for MY 2014, 267 g/mi for MY 2015, and 258 g/mi for preliminary MY 2016. Volkswagen data are included in industry-wide or "All" values. Should the investigation and corrective actions yield different CO$_2$ and fuel economy data, the revised data will be used in future reports.

C. Manufacturer Technology and Attribute Trends

Figure 4.1 shows manufacturer specific MY 2016 production shares for several technologies, as well as the projected industry-wide average production share for each technology. The industry overall has adopted several technologies quickly in recent years, however individual manufacturers are clearly utilizing different technologies to achieve fuel economy (and performance) goals.

Figure 4.1
Manufacturer Adoption of Emerging Technologies for MY 2016
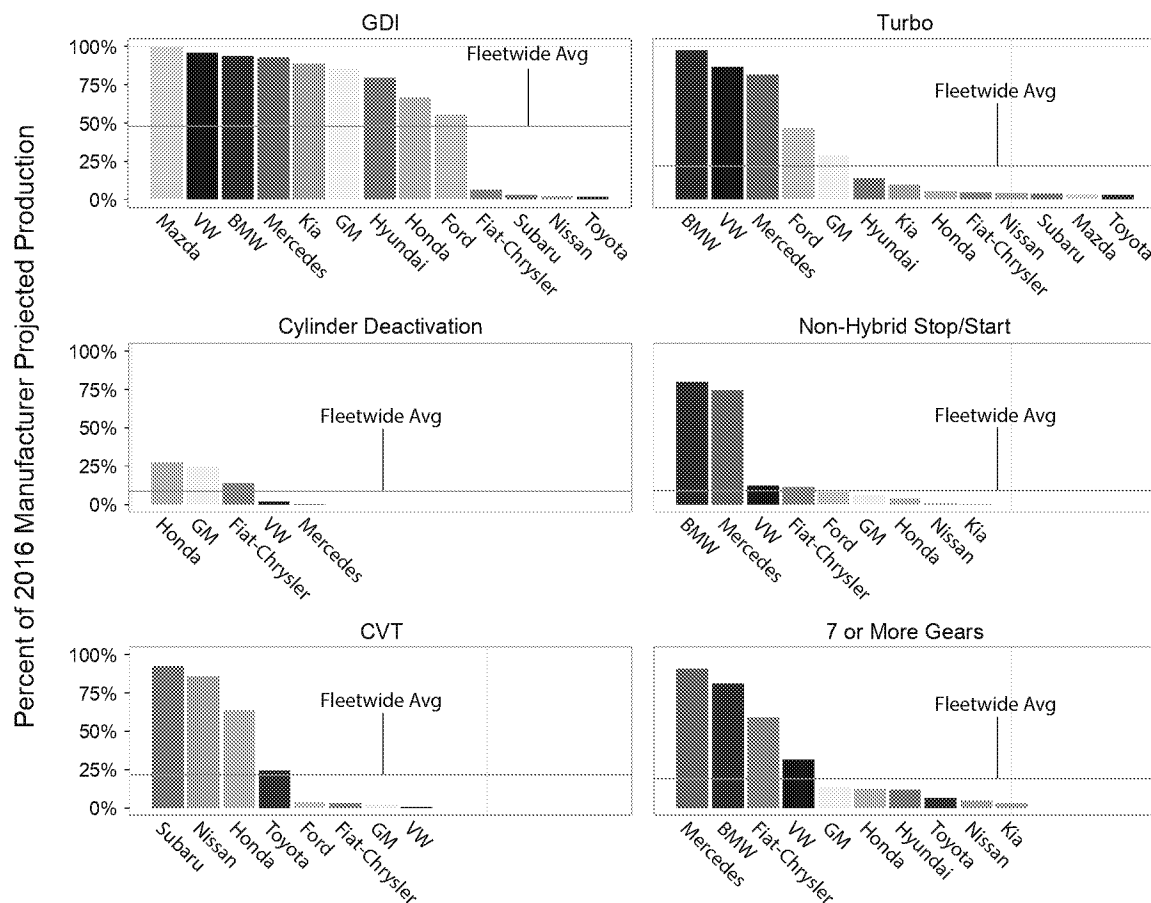
In terms of individual technologies, Mazda had the highest projected production share for gasoline direct injection, BMW for turbocharging and non-hybrid stop/start, Honda for cylinder deactivation, Subaru for continuously variable transmissions, and Mercedes for transmissions with 7 or more gears.

BMW, Mercedes, and VW have technology adoption rates higher than average for four of the six technologies shown in Figure 4.1. GM and Honda have above average rates for three of the

technologies, and Fiat-Chrysler and Ford are each above average for two of the six technologies. It is important to note that the six technologies shown in Figure 4.1 do not represent a comprehensive list of all technologies being applied by manufacturers. Manufacturer adoption rates for some technology approaches, such as the high compression ratios used in the Mazda SKYACTIV engines, are outside the scope of this report. Each of the six technologies shown in Figure 4.1 are discussed in more detail in Section 5.

Table 4.6 shows footprint by manufacturer for MY 2014-2016. Footprint has been relatively stable around 49 square feet. In MY 2015 footprint fell 0.3 square feet to 49.4 square feet. GM had the largest footprint at 53.9 square feet, followed closely by Ford and Fiat-Chrysler. Subaru had the lowest footprint value of about 45 square feet. The remaining manufacturers had average footprint values in the 46 to 49 square feet range.

Table 4.6

Footprint (square feet) by Manufacturer for MY 2014–2016

Manufacturer	MY 2014			MY 2015			Preliminary MY 2016		
	Car	Truck	Car and Truck	Car	Truck	Car and Truck	Car	Truck	Car and Truck
GM	46.3	62.6	53.2	46.7	60.3	53.9	46.4	59.9	51.4
Toyota	45.6	54.1	48.6	45.6	52.2	48.4	45.5	53.2	48.6
Fiat-Chrysler	48.0	54.1	52.2	47.1	52.7	50.7	47.4	53.8	51.1
Ford	46.4	59.4	52.4	46.8	58.9	53.1	46.7	59.4	53.1
Nissan	45.4	51.6	47.2	45.8	50.6	47.1	46.0	50.0	46.8
Honda	45.6	49.2	47.0	45.0	49.1	46.5	45.7	49.5	47.1
Kia	45.8	50.0	46.1	46.2	52.6	46.7	46.0	53.2	46.9
Hyundai	46.1	47.5	46.2	47.2	47.0	47.2	46.7	47.2	46.8
Subaru	44.1	44.4	44.3	44.7	44.7	44.7	44.9	45.0	44.9
VW	45.5	50.0	46.3	45.1	50.1	46.0	45.0	48.8	45.7
BMW	47.1	50.4	47.8	46.6	51.0	47.5	46.8	50.7	47.5
Mercedes	46.6	51.4	47.8	47.3	50.4	48.4	46.6	51.5	47.8
Mazda	45.6	47.2	46.0	46.1	47.1	46.3	46.2	46.8	46.4
Other	45.3	49.2	47.1	45.2	47.9	46.3	50.3	50.6	50.4
All	46.1	55.0	49.7	46.1	53.9	49.4	46.3	54.2	49.3

Manufacturer-specific MY 2015 car footprint values varied little, from about 45 to 47 square feet. MY 2015 truck footprint values were much more variable, ranging from 44.7 (Subaru) to over 60 (General Motors) square feet.

In terms of change in footprint values from MY 2014 to MY 2015, nine manufacturers increased their average footprint, with GM and Ford having the largest increases of 0.7 square feet. Four manufacturers decreased their average footprint, with Honda reducing average footprint by 0.5 square feet. Industry-wide footprint is projected to decrease slightly in MY 2016.

Table 4.7 shows manufacturer-specific values for adjusted fuel economy and production share for the two classes (cars and trucks) and the five vehicle types (cars, car SUVs, truck SUVs, pickups, and minivans/vans) for 13 manufacturers for MY 2014. Mazda had the highest adjusted fuel economy for the car type and Honda had the highest fuel economy for car SUVs. For the truck types, Subaru reported the highest adjusted fuel economy for truck SUVs, GM had the highest pickup fuel economy, and Nissan had the highest adjusted fuel economy for minivans/vans. Subaru had the highest truck share of 72%, followed by Chrysler-Fiat at 65%, while Hyundai and Kia had truck shares below 10%.

Industry-wide, car type vehicles averaged 4.1 mpg higher than car SUVs in MY 2015, which is unchanged since MY 2014. Among truck types, truck SUVs had the highest adjusted fuel economy of 22.0 mpg, followed by minivans/vans at 21.9 mpg, and pickups at 18.8 mpg. The vehicle types with the biggest fuel economy increases since MY 2015 were pickups at 0.8 mpg and both car and car SUVs at 0.7 mpg.

Table 4.7
Adjusted Fuel Economy and Production Share by Vehicle Classification and Type for MY 2015*

Manufacturer	Car (Non-SUV) Adj FE (MPG)	Car (Non-SUV) Prod Share	Car SUV Adj FE (MPG)	Car SUV Prod Share	All Car Adj FE (MPG)	All Car Prod Share	Truck SUV Adj FE (MPG)	Truck SUV Prod Share	Pickup Adj FE (MPG)	Pickup Prod Share	Minivan/Van Adj FE (MPG)	Minivan/Van Prod Share	All Truck Adj FE (MPG)	All Truck Prod Share
GM	27.0	31.2%	24.9	15.4%	26.3	46.6%	20.0	27.8%	19.5	25.6%	13.3	0.1%	19.7	53.4%
Toyota	31.7	47.6%	24.9	9.9%	30.3	57.5%	21.9	25.1%	17.6	10.9%	21.1	6.5%	20.5	42.5%
Fiat-Chrysler	25.7	27.1%	25.4	8.2%	25.6	35.3%	20.6	43.7%	18.2	11.7%	21.0	9.3%	20.2	64.7%
Ford	28.0	36.7%	24.9	11.1%	27.2	47.7%	20.9	25.9%	19.0	23.5%	23.0	2.9%	20.1	52.3%
Nissan	32.1	63.1%	27.7	8.6%	31.5	71.6%	23.6	20.8%	18.1	4.4%	24.9	3.1%	22.6	28.4%
Honda	32.1	55.5%	28.7	9.2%	31.6	64.7%	25.5	27.1%	-	-	23.2	8.2%	24.9	35.3%
Kia	28.0	74.8%	22.7	17.9%	26.8	92.7%	22.8	3.0%	-	-	20.9	4.3%	21.6	7.3%
Hyundai	29.3	81.0%	23.4	12.6%	28.4	93.5%	21.5	6.5%	-	-	-	-	21.5	6.5%
Subaru	28.9	28.2%	-	-	28.9	28.2%	28.2	71.8%	-	-	-	-	28.2	71.8%
BMW	27.4	79.1%	28.0	0.5%	27.4	79.5%	22.8	20.5%	-	-	-	-	22.8	20.5%
Mercedes	25.9	60.6%	22.1	4.6%	25.6	65.2%	20.4	34.8%	-	-	-	-	20.4	34.8%
Mazda	33.3	57.0%	28.5	15.4%	32.1	72.4%	24.6	24.4%	-	-	24.8	3.2%	24.7	27.6%
Other	33.2	45.1%	27.9	15.0%	31.7	60.0%	22.0	40.0%	-	-	-	-	22.0	40.0%
All	29.4	47.2%	25.3	10.2%	28.6	57.4%	22.0	28.1%	18.8	10.7%	21.9	3.9%	21.1	42.6%

* Note: Volkswagen is not included in this table due to an ongoing investigation. Based on initial certification data, Volkswagen values are 28.6 mpg at 79.2% production share for cars, 23.0 mpg at 2.1% production share for car SUVs, 28.4 mpg at 81.3% production share for all cars, and 21.6 mpg at 18.7% production share for both truck SUVs and all trucks. Volkswagen data are included in industry-wide or "All" values. Should the investigation and corrective actions yield different CO_2 and fuel economy data, the revised data will be used in future reports.

Table 4.8 shows average MY 2015 manufacturer-specific values, for all cars and trucks, for three important vehicle attributes: footprint, weight, and horsepower. The footprint data in Table 4.8 were also shown in Table 4.6 and discussed above. GM had the highest average weight of 4602 pounds, followed by Mercedes and Fiat-Chrysler. Hyundai, Mazda, and Kia reported the lowest average weights of around 3400 pounds. Mercedes had the highest average horsepower level of 285 hp, followed by Ford, and BMW. Subaru reported the lowest horsepower level of 177 hp, followed by Mazda.

Table 4.8

Vehicle Footprint, Weight, and Horsepower by Manufacturer for MY 2015

Manufacturer	Footprint (sq ft)	Weight (lbs)	HP
GM	53.9	4602	272
Toyota	48.4	3958	206
Fiat-Chrysler	50.7	4321	261
Ford	53.1	4272	263
Nissan	47.1	3643	189
Honda	46.5	3639	194
Kia	46.7	3453	187
Hyundai	47.2	3480	191
Subaru	44.7	3648	177
VW	46.0	3852	211
BMW	47.5	4006	263
Mercedes	48.4	4358	285
Mazda	46.3	3473	178
All	**49.4**	**4035**	**229**

Finally, Figure 4.2 provides a historical perspective, for both adjusted fuel economy and truck share, for each of the top 13 manufacturers. Adjusted fuel economy is presented for cars only, trucks only, and cars and trucks combined. One noteworthy result in Figure 4.2 is that there is very little difference between the adjusted fuel economy values for Subaru cars and trucks, the only manufacturer for which this is the case.

More information for the historic Trends database stratified by manufacturer can be found in Appendices J and K.

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Figure 4.2

Adjusted Fuel Economy and Percent Truck by Manufacturer for MY 1975–2016
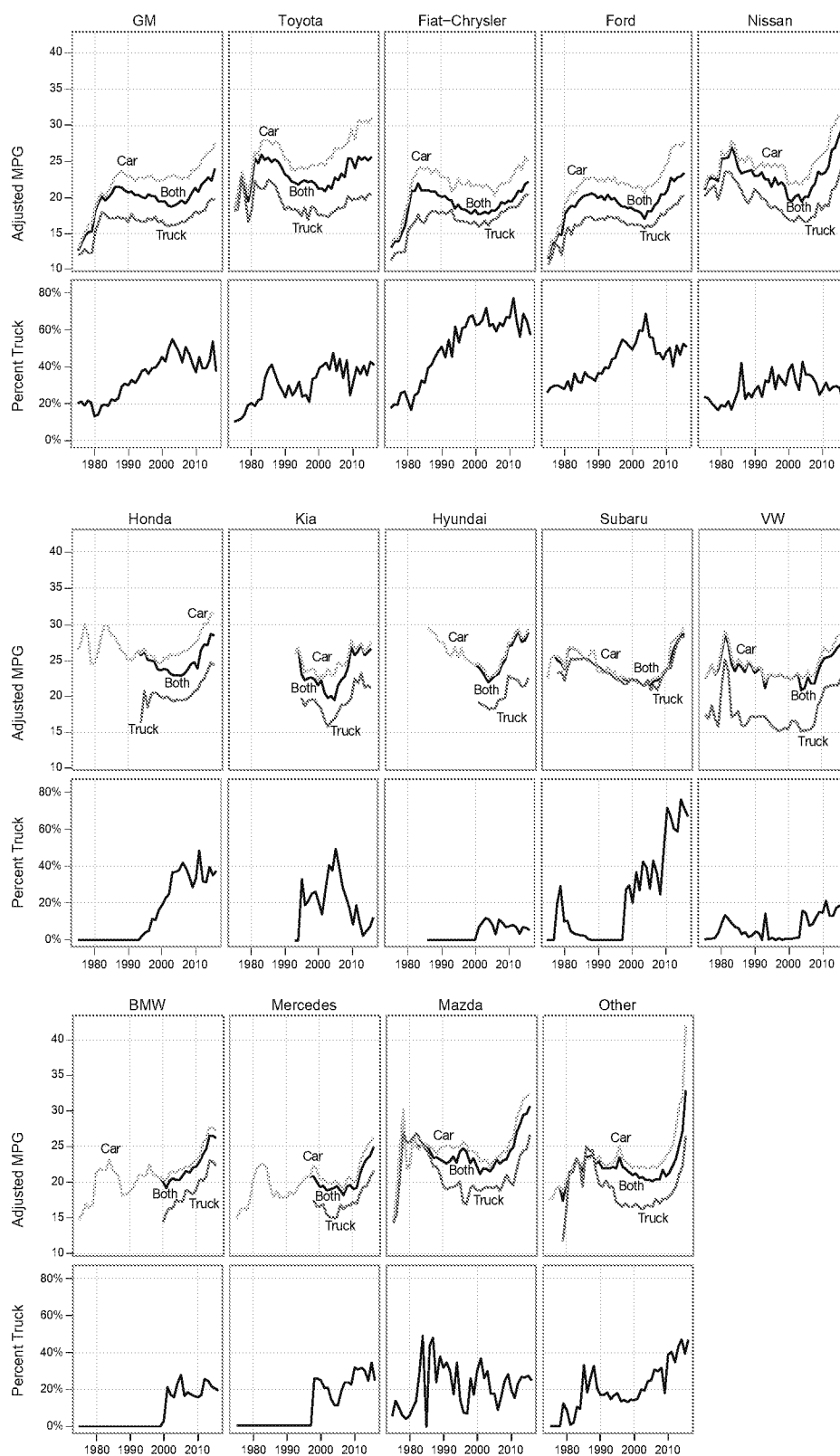
D. Manufacturer Specific Impact of Alternative Fuel Vehicles

In the past, this report has treated alternative fuel vehicles separately from gasoline and diesel vehicles, with the vast majority of analysis limited to gasoline and diesel vehicles only. Since alternative fuel vehicle production has generally been less than 0.1% of total vehicle production until very recently, the impact of excluding alternative fuel vehicles was negligible. However, with alternative fuel vehicles now approaching 1% of new vehicle production, these vehicles are in fact beginning to have a measurable and meaningful impact on overall new vehicle fuel economy and CO_2 emissions, particularly for some individual manufacturers.

This section summarizes the impact of alternative fuel vehicles on individual manufacturer fuel economy and CO_2 emissions. In order for data from alternative fuel vehicles to be merged with data for gasoline and diesel vehicles, this report uses miles per gallon-equivalent (mpge), which is defined as the number of miles that a vehicle travels on an amount of alternative fuel with the same energy content as a gallon of gasoline, and tailpipe CO_2 emissions data. These values are used on the EPA/DOT Fuel Economy and Environment Label and are the metrics that are most often associated with these vehicles. Of course, including net upstream CO_2 emissions for vehicles operating on electricity would change the impact of electric and plug-in hybrid electric vehicles on manufacturer-specific CO_2 emissions (see Section 7 for data on net upstream CO_2 emissions).

Table 4.9 shows the impact of alternative fuel vehicles on MY 2015 manufacturer-specific adjusted mpg and CO_2 emissions values. Eleven of the thirteen largest manufacturers produced alternative fuel vehicles in MY 2015. Additionally, two smaller manufacturers also produced alternative fuel vehicles and are included in Table 4.9. The alternative fuel vehicle fuel economy and CO_2 emissions values were recalculated from label values (weighted 55% city/45% highway) to adjusted values (weighted 43% city/57% highway) to be consistent with the adjusted numbers presented in most of the sections of this report. For further discussion of the methodology behind the adjusted fuel economy and CO_2 values, see Section 10.

Table 4.9

MY 2015 Alternative Fuel Vehicle Impact on Manufacturer Averages*

Manufacturer	Adj. Fuel Economy (MPG)			Adjusted CO_2 Emissions (g/mi)			Total AFV Production	Percent of Manufacturer Production
	Without AFVs	With AFVs	Difference with AFVs	Without AFVs	With AFVs	Difference with AFVs		
Tesla	-	97.1	-	-	0	-	24,322	100.0%
McLaren	18.9	18.7	-0.2	470	471	0	76	12.2%
BMW	25.9	26.3	0.4	345	338	-7	11,386	2.7%
Nissan	27.9	28.3	0.4	318	312	-6	33,242	2.0%
Ford	22.8	23.0	0.1	389	387	-2	17,384	0.9%
Mercedes	23.4	23.5	0.1	382	379	-3	3,125	0.9%
GM	22.2	22.3	0.1	400	398	-2	15,072	0.5%
Fiat-Chrysler	21.8	21.8	0.1	408	407	-1	7,825	0.4%
Toyota	25.1	25.2	0.0	354	353	0	5,838	0.2%
Kia	26.3	26.3	0.0	338	338	0	926	0.1%
Honda	28.9	28.9	0.0	308	308	0	300	0.0%
Hyundai	27.8	27.8	0.0	320	320	0	72	0.0%
All	**24.7**	**24.8**	**0.1**	**360**	**358**	**-2**	**119,568**	**0.7%**

*Note: Volkswagen is not included in this table due to an ongoing investigation. Based on initial certification data, Volkswagen values are 26.7 mpg and 338 g CO_2/mi, without AFVs and 26.8 mpg and 336 g CO_2/mi with AFVs. AFVs are 0.8% share of Volkswagen's production. These Volkswagen data are included in industry-wide or "All" values. Should the investigation and corrective actions yield different CO_2 and fuel economy data, the revised data will be used in future reports.

Alternative fuel vehicles comprised 0.7% of new vehicle production in MY 2015. Including mpge and tailpipe CO_2 emissions from alternative fuel vehicles increased the overall MY 2015 adjusted fuel economy by 0.1 mpg compared to what it otherwise would have been, and reduced overall CO_2 emissions by 2 g/mi. Of the largest manufacturers with production of over 100,000 vehicles, BMW had the highest concentration of alternative fuel vehicle production at 2.7%, followed by Nissan at 2% and both Mercedes and Ford at around 1%. Including alternative fuel vehicles improved BMW's and Nissan's performance the most, increasing MY 2015 fuel economy by 0.4 mpg overall, and decreasing CO_2 emissions by 6-7 g/mi. The inclusion of alternative fuel vehicles raised adjusted fuel economy by 0.1 mpg, and decreased tailpipe CO_2 emissions by 1-4 g/mi, for Ford, Mercedes, GM, and Fiat-Chrysler.

Tesla, which exclusively sells EVs, was the one small manufacturer with significant alternative fuel vehicle production. Mitsubishi, McLaren, and BYD reported very low alternative fuel vehicle production.

The impact of alternative fuel vehicles on most manufacturer values is still relatively small, and does not result in major changes in the manufacturer rankings for either adjusted fuel economy or adjusted CO_2 emissions shown in Tables 4.2 and 4.3.

Section 7 of this report has further data on fuel economy, emissions, and other parameters for alternative fuel vehicles.

5 Powertrain Technologies

Technological innovation is a major driver of vehicle design in general, and vehicle fuel economy and CO_2 emissions in particular. Since its inception, this report has tracked the usage of key technologies as well as many major engine and transmission parameters. This section of the report will focus on the larger technology trends in engine and transmission production and the impact of those trends on vehicle fuel economy and CO_2 emissions.

Over the last 40 years, one trend is strikingly clear: automakers have consistently developed and commercialized new technologies that have provided increasing benefits to consumers. As discussed previously in Sections 2 and 3, the benefits provided by new technologies have varied over time. New technologies have been introduced for many reasons, including increasing fuel economy, reducing CO_2 emissions, increasing vehicle power and performance, increasing vehicle content and weight, or improving other vehicle attributes that are not easily quantifiable (e.g., handling, launch feel).

Data from alternative fuel vehicles (AFVs) are included in the report beginning with MY 2011 data. AFVs include electric vehicles (EVs), plug-in electric hybrids (PHEVs), hydrogen fuel cell vehicles (FCVs), and compressed natural gas (CNG) vehicles. AFVs are projected to surpass 1% of production in MY 2016. AFV production has increased in recent years and is enough to begin impacting some important trends in this report. However, making technical comparisons between AFVs and conventional vehicles is difficult due to the fact that many conventional metrics are no longer relevant for electrified vehicles (number of cylinders, for example), and that some AFVs have complex operating cycles based on multiple fuels. For these reasons, the analysis in part B of this section is limited to conventional vehicles (gasoline, diesel, and gasoline hybrid) only. Part C focuses exclusively on alternative fuel vehicles, without conventional vehicles. The rest of this section includes AFVs and conventional vehicles together. For a more detailed description of individual AFVs and the parameters used to measure fuel economy and emissions, see section 7.

A. Overall Engine Trends

Engine technology has changed radically over the last 40 years. In 1975, the first year of this report, nearly all engines were carbureted with fixed valve timing and two valves per cylinder. In MY 2016, almost half of new vehicle production will feature engines with gasoline direct injection, variable valve timing, and multiple valves per cylinder. In addition, advanced AFVs, including PHEVs that can operate on electricity or gasoline, are in production today.

The evolution of vehicle engine technology over the last 40 years is shown in Figure 5.1. Engine technology has consistently changed as the industry evolved. One interesting aspect of Figure 5.1 is that engine technology has, at times, changed quite quickly. GDI engines were installed in less than 3% of vehicles produced in MY 2008, but are projected to reach about 49% of new vehicles in MY 2016. This is a rapid change, but not unprecedented in the industry. For example, nearly all trucks replaced carburetors with fuel injection engines in the 5 year period from MY 1985 to MY 1990.

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Figure 5.1
Production Share by Engine Technology

Fuel Delivery	Valve Timing	Number of Valves	Key
Carbureted	Fixed	Two-Valve	1
		Multi-Valve	2
Throttle Body Injection	Fixed	Two-Valve	3
		Multi-Valve	4
Port Fuel Injection	Fixed	Two-Valve	5
		Multi-Valve	6
	Variable	Two-Valve	7
		Multi-Valve	8
Gasoline Direct Injection (GDI)	Fixed	Multi-Valve	9
		Two-Valve	10
	Variable	Multi-Valve	11
		Two-Valve	12
Diesel	—	—	13
Alternative Fuel	—	—	14

Table 5.1

Production Share by Powertrain

Model Year	Gasoline	Hybrid	Diesel	Plug-in Hybrid Electric	Electric	Other
1975	99.8%	--	0.2%	-	-	-
1976	99.8%	--	0.2%	-	-	-
1977	99.6%	-	0.4%	-	-	-
1978	99.1%	-	0.9%	-	-	-
1979	98.0%	-	2.0%	-	-	-
1980	95.7%	-	4.3%	--	--	-
1981	94.1%	-	5.9%	-	-	-
1982	94.4%	--	5.6%	-	-	-
1983	97.3%	--	2.7%	-	-	-
1984	98.2%	--	1.8%	-	-	-
1985	99.1%	-	0.9%	-	-	-
1986	99.6%	-	0.4%	--	--	--
1987	99.7%	-	0.3%	-	-	--
1988	99.9%	-	0.1%	-	-	-
1989	99.9%	-	0.1%	-	-	-
1990	99.9%	--	0.1%	-	-	-
1991	99.9%	-	0.1%	-	-	-
1992	99.9%	-	0.1%	-	-	-
1993	100.0%	-	--	--	--	-
1994	100.0%	-	0.0%	-	-	-
1995	100.0%	-	0.0%	-	-	-
1996	99.9%	-	0.1%	-	-	-
1997	99.9%	--	0.1%	-	-	-
1998	99.9%	-	0.1%	-	-	-
1999	99.9%	-	0.1%	-	-	-
2000	99.8%	0.0%	0.1%	--	--	--
2001	99.7%	0.1%	0.1%	-	-	-
2002	99.6%	0.2%	0.2%	-	-	-
2003	99.5%	0.3%	0.2%	-	-	-
2004	99.4%	0.5%	0.1%	-	-	-
2005	98.6%	1.1%	0.3%	-	-	-
2006	98.1%	1.5%	0.4%	-	-	-
2007	97.7%	2.2%	0.1%	-	-	--
2008	97.4%	2.5%	0.1%	-	-	-
2009	97.2%	2.3%	0.5%	-	-	-
2010	95.5%	3.8%	0.7%	-	-	0.0%
2011	97.0%	2.2%	0.8%	0.0%	0.1%	0.0%
2012	95.5%	3.1%	0.9%	0.3%	0.1%	0.0%
2013	94.8%	3.6%	0.9%	0.4%	0.3%	0.0%
2014	95.7%	2.6%	1.0%	0.4%	0.3%	0.0%
2015	95.9%	2.4%	0.9%	0.3%	0.5%	0.0%
2016 (prelim)	*95.1%*	*2.5%*	*0.7%*	*0.4%*	*1.3%*	*0.0%*

Gasoline combustion engines have long dominated sales in the United States. As shown in Table 5.1, non-hybrid gasoline engines are projected to be installed in 95.1% of all new vehicles in MY 2016. Gasoline hybrid vehicles are projected to account for less than 3% of new vehicles in MY 2016, with electric vehicles (EVs) and plug-in electric hybrids (PHEVs) capturing 1.3% and 0.4% of production. Diesel vehicles are projected to account for 0.7% of production, well below the 5.9% record high set in MY 1981. Hybrids are also below their record production level of MY 2010.

B. Trends in Conventional Engines

Conventional engine technologies include gasoline vehicles, diesel vehicles, and gasoline hybrid vehicles. In MY 2016, these vehicles are projected to account for slightly less than 99% of vehicles produced. These vehicles all rely on combustion engines and either gasoline or diesel fuel to power the vehicle. Many of the metrics in this section, such as engine displacement, are not relevant for AFVs, so the analysis presented here excludes all AFVs. It is important to note that, because AFVs are excluded from this section, some values in this section will differ slightly from those cited elsewhere in this report where AFVs are included.

Horsepower and Displacement

One of the most remarkable trends over the course of this report is the increase in vehicle horsepower since the early 1980s. From 1975 through the early 1980s, average horsepower decreased, in combination with lower vehicle weight (see Table 2.1 and Figure 2.3) and smaller engine displacement (see below). Since the early 1980s, the average new vehicle horsepower has more than doubled. Average horsepower climbed consistently from MY 1982 to MY 2008. Since MY 2008, horsepower trends have been less consistent, and may be beginning to flatten out. Average horsepower for conventional vehicles is projected to be 229 hp in MY 2016, just below record highs. The long-term trend in horsepower is mainly attributable to improvements in engine technology, but increasing production of larger vehicles and an increasing percentage of truck production have also influenced the increase of average new vehicle horsepower. The trend in average new vehicle horsepower is shown in Figure 5.2.

Engine size, as measured by total displacement, is also shown in Figure 5.2. Three general phases in engine displacement are discernible. From MY 1975 to 1987, the average engine displacement of new vehicles dropped dramatically by nearly 40%. From MY 1988 to 2004, displacement generally grew slowly, but the trend reversed in 2005 and engine displacement has been generally decreasing since. In MY 2016, engine displacement is projected to reach the lowest point on record, below the previous lowest average displacement reached in MY 1987.

The contrasting trends in horsepower (near an all-time high) and engine displacement (near an all-time low) highlight the continuing improvement in engines due to introduction of new technologies (e.g., increasingly sophisticated fuel injection designs) and smaller engineering improvements that are not tracked by this report (e.g., reduced internal friction). One

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additional way to examine the relationship between engine horsepower and displacement is to look at the trend in *specific* power, which is a metric to compare the power output of an engine relative to its size. Here, engine specific power is defined as horsepower divided by displacement.

Figure 5.2
Engine Power and Displacement, AFVs Excluded
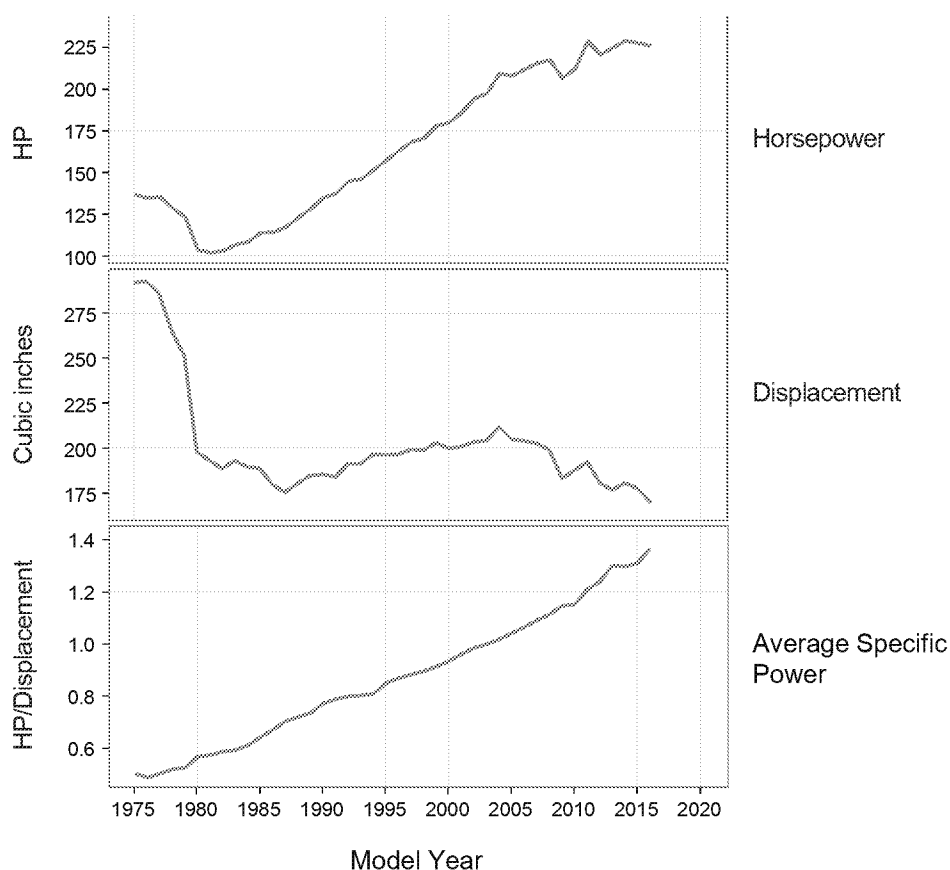
Since the beginning of this report, the average specific power of engines across the new vehicle fleet has increased at a remarkably steady rate, as shown in Figure 5.2. Since MY 1975, the specific power of new vehicle engines has increased by about 0.02 horsepower per cubic inch every year. Considering the numerous and significant changes to engines over this time span, changes in consumer preferences, and the external pressures on vehicle purchases, the long standing linearity of this trend is noteworthy. The roughly linear increase in specific power does not appear to be slowing. Turbocharged engines, direct injection, higher compression ratios, and many other engine technologies are likely to continue increasing engine specific power.

Figure 5.3 summarizes three important engine metrics, each of which has shown a remarkably linear change over time. Specific power, as discussed above, has increased more than 150% since MY 1975 and at a very steady rate. The amount of fuel consumed by an engine, relative to the total displacement, has fallen about 15% since MY 1975, and fuel consumption relative to engine horsepower has fallen nearly 65% since MY 1975. Taken as a whole, the trend lines in Figure 5.3 clearly show that engine improvements over time have been steady, continual, and have resulted in impressive improvements to internal combustion engines.

Figure 5.3

Percent Change for Specific Engine Metrics, AFVs Excluded

Model Year
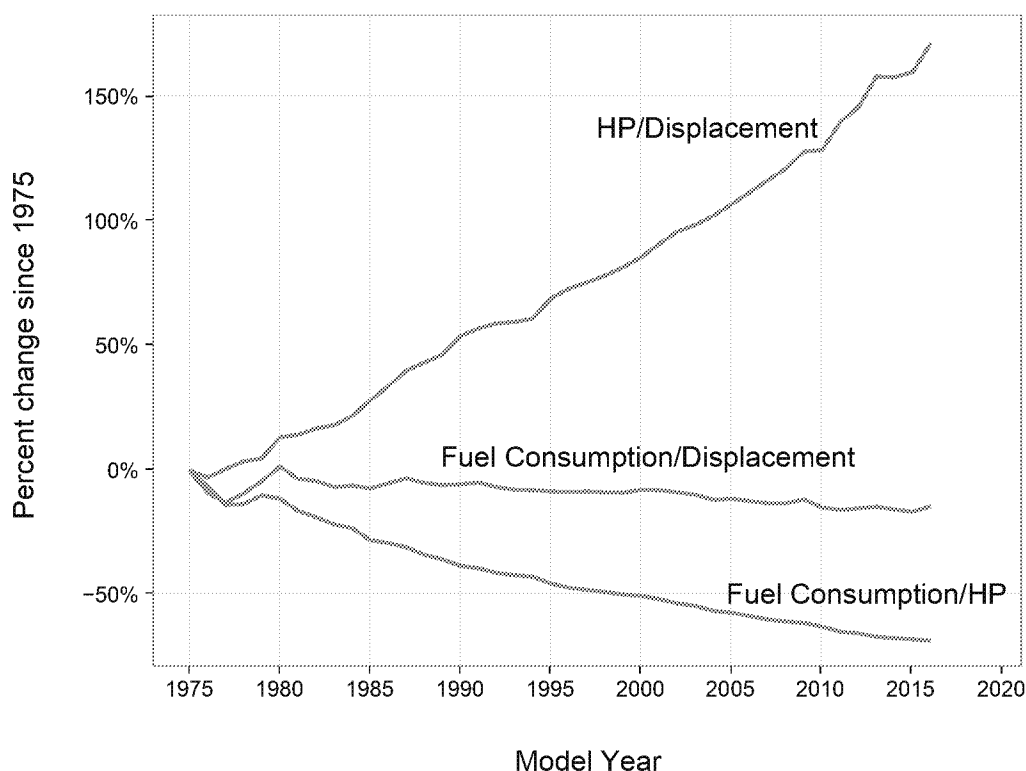
Another fundamental design parameter for internal combustion engines is the number of cylinders. Since 1975, there have been significant changes to the number of cylinders in new vehicles, as shown in Figure 5.4. In the mid and late 1970s, the 8-cylinder engine was dominant, accounting for over half of new vehicle production. In MY 1980 there was a significant change in the market, as 8-cylinder engine production share dropped from 54% to 26% and 4-cylinder production share increased from 26% to 45%. The 4-cylinder engine then continued to lead the market until overtaken by 6-cylinder engines in MY 1992. Model year 2009 marked a second major shift in engine production, as 4-cylinder engines once again became the production leader with a 51% market share (an increase of 13 percentage points in a single year), followed by 6-cylinder engines with 35%, and 8-cyinder engines at 12%. Production share of 4-cylinder engines has generally increased since, and is at the highest point on record, accounting for 58% of production in MY 2015. Production share of 8-cylinder

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engines has continued to decrease, to less than 11%. Projected data for MY 2016 suggests that these trends will continue.

Engine displacement per cylinder has been relatively stable over the time of this report (around 35 cubic inches per cylinder since 1980), so the reduction in overall new vehicle engine displacement shown in Figure 5.2 is almost entirely due to the shift towards engines with fewer cylinders. In MY 2016, the production share of three cylinder engines is projected to be slightly less than 0.5%, but growing.

Figure 5.4
Production Share by Number of Engine Cylinders, AFVs Excluded
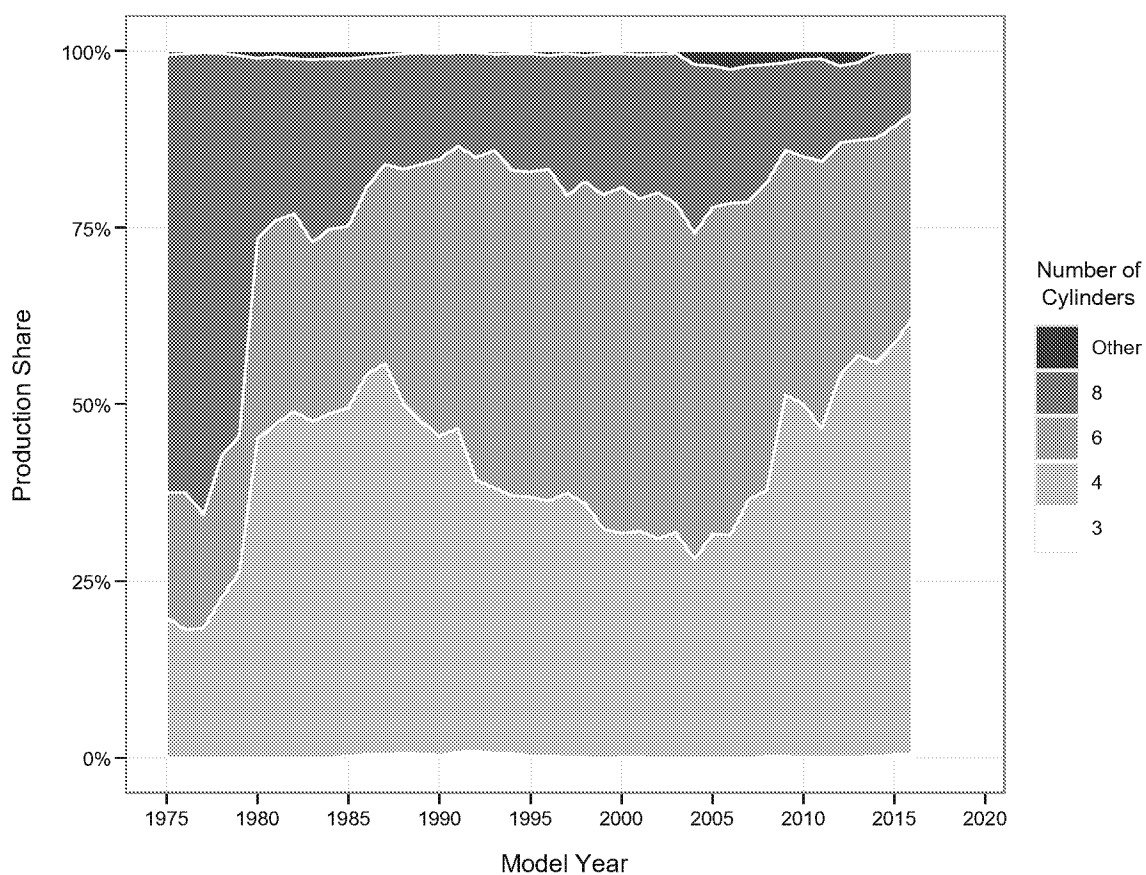
Fuel Delivery Systems

One aspect of engine design that has changed significantly over time is how fuel is delivered into the engine. In the 1970s and early 1980s, nearly all engines used carburetors to meter fuel delivered to the engine. Carburetors were replaced over time with throttle body injection systems (TBI) and port fuel injection systems. More recently, engines with gasoline direct injection (GDI) have begun to replace engines with port fuel injection. Engines using GDI were first introduced into the market with very limited production in MY 2007. Only 8 years later GDI engines were installed in about 42% of MY 2015 vehicles, and are projected to achieve a 49% market share in MY 2016.

Another key aspect of engine design is the valve-train. The number of valves per cylinder and the ability to alter valve timing during the combustion cycle can result in significant power and efficiency improvements. This report began tracking multi-valve engines (i.e., engines with more than 2 valves per cylinder) for cars in MY 1986 (and for trucks in MY 1994), and since that time nearly the entire fleet has converted to multi-valve design. While some three and five valve engines have been produced, the vast majority of multi-valve engines are based on 4 valves per cylinder. In addition to the number of valves per cylinder, designs have evolved that allow engine valves to vary the timing when they are opened or closed with respect to the combustion cycle, creating more flexibility to control engine efficiency, power, and emissions. This report began tracking variable valve timing (VVT) for cars in MY 1990 (and for trucks in MY 2000), and since then nearly the entire fleet has adopted this technology. Figure 5.1 shows the evolution of engine technology, including fuel delivery method and the introduction of VVT and multi-valve engines.

As clearly shown in Figure 5.1, fuel delivery and valve-train technologies have often developed over the same time frames. Nearly all carbureted engines relied on fixed valve timing and had two valves per cylinder, as did early port injected engines. Port injected engines largely developed into engines with both multi-valve and VVT technology. Engines with GDI are almost exclusively using multi-valve and VVT technology. These four engine groupings, or packages, represent a large share of the engines produced over the lifetime of the Trends database.

Figure 5.5 shows the changes in specific power and fuel consumption between each of these engine packages over time. There is a very clear increase in specific power of each engine package, as engines moved from carbureted engines, to two-valve port fixed engines, to multi-valve port VVT engines, and finally to GDI engines. Some of the increase for GDI engines may also be due to the fact that GDI engines are often paired with turbochargers to further increase power. Figure 5.5 also shows the reduction in fuel consumption per horsepower for each of the four engine packages.

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Figure 5.5

Engine Metrics for Different Engine Technology Packages, AFVs Excluded
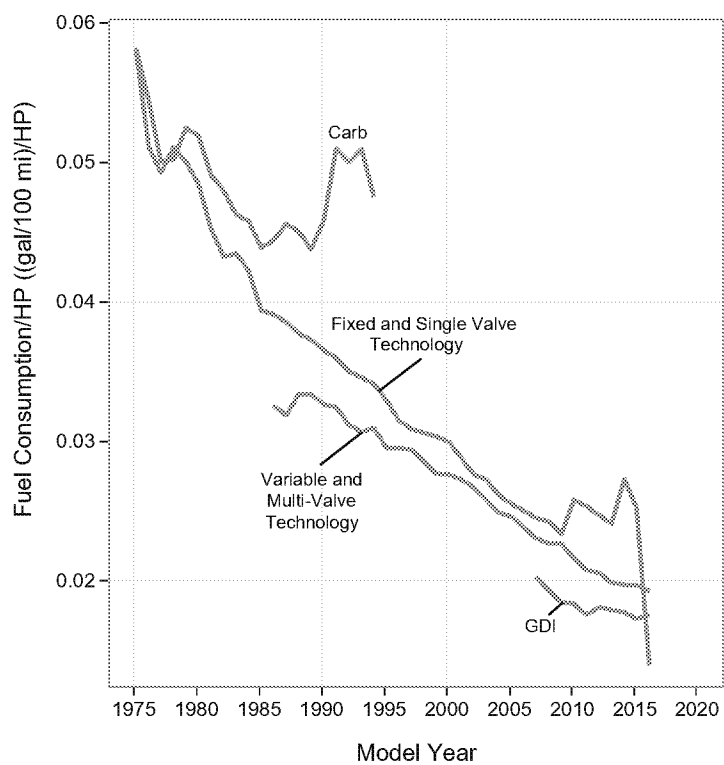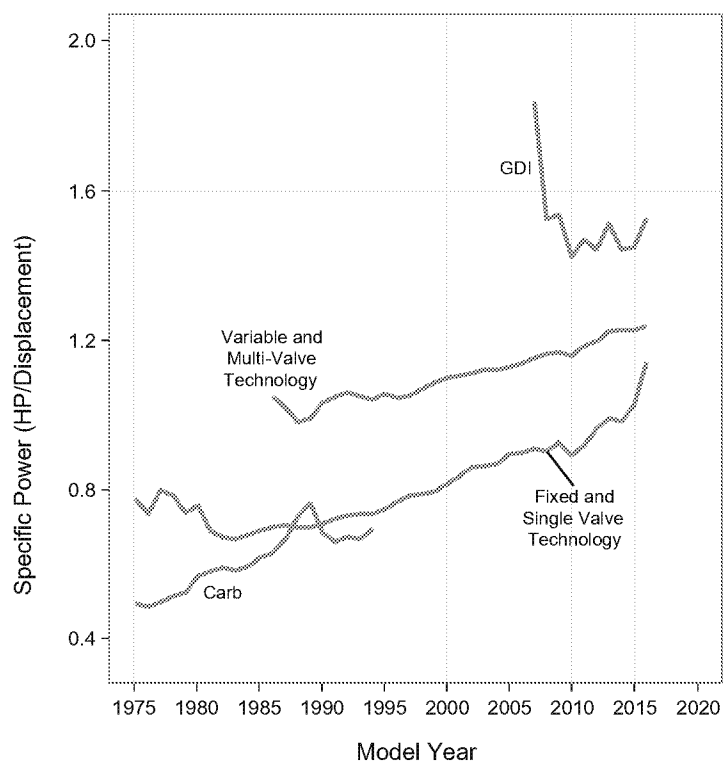
Turbo-Downsizing

Many manufacturers have introduced engines that are considered "turbo downsized" engines. This group of engines generally has three common features: a smaller displacement than the engines they are replacing, turbochargers, and (often, but not always) GDI. Turbo downsized engines are an approach to engine design that provides increased fuel economy by using a smaller engine for most vehicle operation, while retaining the ability to provide more power via the turbocharger, when needed.

Turbocharged engines are projected to capture approximately 22% of new vehicle production in MY 2016, with all of the 13 largest manufacturers (as discussed in Section 4) offering turbocharged engine packages. This is a significant increase in market penetration over the last decade, and it is a trend that appears to be accelerating rapidly, as shown in Figure 5.6. Prior to the last few years, turbochargers (and superchargers) were available, but generally only on high performance, low volume vehicles. It is only in the last few years that turbochargers have been available as part of a downsized turbo vehicle package, many of which are now available in mainstream vehicles. The sales of these vehicles are driving the increase in turbocharger market share. Both cars and trucks have rapidly added turbocharged engine packages, as shown in Figure 5.6.

Figure 5.6
Market Share of Gasoline Turbo Vehicles
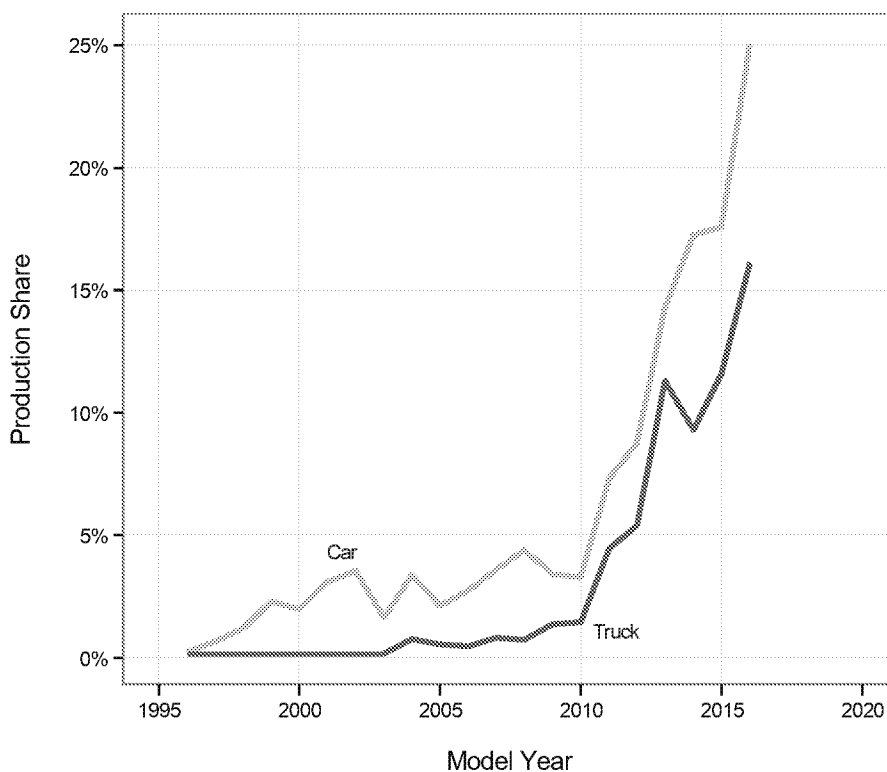
Turbochargers are most frequently combined with 4-cylinder engines. Excluding diesel engines, 76% of turbocharged engines are combined with 4-cylinder engines and about 19% are combined with 6-cylinder engines. Over 60% of turbocharged engines are projected to be installed in 4-cylinder cars in MY 2016. The overall breakdown of turbocharger distribution in the new vehicle fleet is shown in Table 5.2.

In current engines, turbochargers are often being used in combination with GDI to allow for more efficient engine operation and to increase the resistance to engine knock (the use of variable valve timing also helps to reduce turbo lag). In MY 2016, more than 90% of new vehicles with gasoline turbocharged engines also use GDI.

Table 5.2

Distribution of MY 2016 (Preliminary) Gasoline Turbocharged Engines

Category	Turbo Share
Car	
4 cylinder Car	63.0%
6 cylinder Car	4.5%
8 cylinder Car	2.0%
Other Car	2.3%
Truck	
4 cylinder Truck	13.1%
6 cylinder Truck	14.4%
8 cylinder Truck	0.5%
Other Truck	0.2%

Figure 5.7 examines the distribution of engine displacement and power of turbocharged engines for MY 2010 (top) to MY 2016 (bottom). Note that the production values for cars and trucks in each bar are additive, e.g., there are projected to be about 950,000 gasoline cars with turbochargers in the 200-300 horsepower range in MY 2016, with another 385,000 gasoline trucks with turbochargers in the same horsepower range. In MY 2010, turbochargers were used mostly on cars, and were available on engines both above and below the average engine displacement. The biggest increase in turbocharger use over the last few years has been in cars with engine displacement well below the average displacement. Engine horsepower has been more distributed around the average, reflecting the higher power per displacement of turbocharged engines. This trend towards adding turbochargers to smaller, less powerful engines reinforces the conclusion that most turbochargers are currently being used for turbo downsizing, and not simply just to add power for performance vehicles.

Figure 5.7

Distribution of Gasoline Turbo Vehicles by Displacement and Horsepower, MY 2010, 2013, and 2016
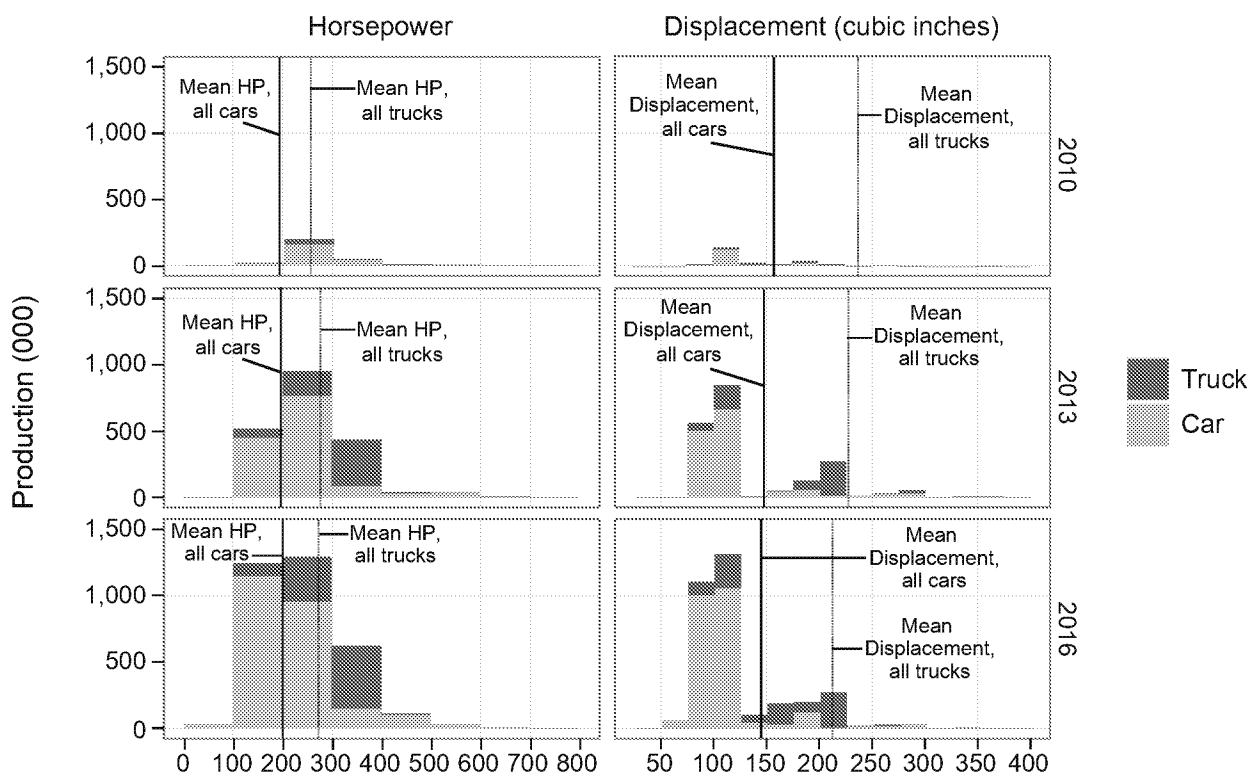
Hybrids

Hybrid vehicles utilize larger battery packs, electric motor(s), and other components that can increase vehicle fuel economy. Benefits of hybrids include: 1) regenerative braking which can capture energy that is otherwise lost in conventional friction braking to charge the battery, 2) availability of two sources of on-board power which can allow the engine to be operated at or near its peak efficiency more often, and 3) shutting off the engine at idle. The introduction of the first hybrid into the U.S. marketplace occurred in MY 2000 with the Honda Insight. Hybrid production and market share increased throughout the 2000s, with hybrid production peaking in MY 2013 at over 500,000 units, as shown in Figure 5.8, and market share peaking in MY 2010 at 3.8%. In the last few years, hybrid production has fluctuated, with hybrids accounting for 2.4% market share in MY 2015. Their market share is projected to reach 2.5% in MY 2016. A large factor in the fluctuating hybrid production is the fact that hybrid sales are still largely dominated by one vehicle, the Toyota Prius. Production of the Toyota Prius, like many other vehicles produced in Japan, was impacted by the earthquake and tsunami that hit Japan in 2011, as well as by a shortened model year in MY 2009 due to the introduction of a redesigned vehicle.

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Figure 5.8

Hybrid Production MY 2000–2016 (With 3-Year Moving Average), AFVs Excluded
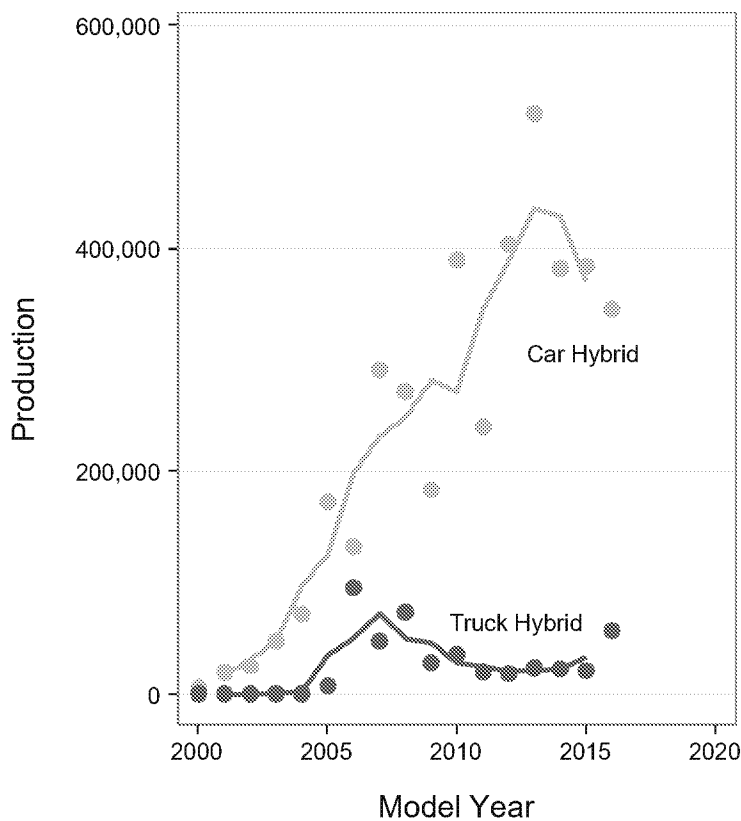
The first U.S. hybrid vehicle in MY 2000, the Honda Insight, was a low production, specialty vehicle with very high fuel economy (Table 10.2 shows various fuel economy metrics for the 2005 Insight). The Toyota Prius was first introduced in the U.S. market in MY 2001, and over time, more hybrid models were introduced. Hybrids now represent a much broader range of vehicle types and are now frequently offered as powertrain options on many popular models that are nearly indistinguishable from their non-hybrid counterparts. Most hybrids provide higher fuel economy than comparable vehicles, although some hybrids have been offered as more performance-oriented vehicles with more minor fuel economy improvements.

Figure 5.9 shows the production-weighted distribution of fuel economy for all hybrid cars by year. Hybrid cars, on average, have fuel economy more than 50% higher than the average non-hybrid car in MY 2016. As a production weighted average, hybrid cars achieved 43 mpg for MY 2016, while the average non-hybrid car achieved about 29 mpg. From MY 2000 to MY 2016, the number of hybrid models available increased from 1 to 33. The increasing spread between the highest and lowest fuel economy of available hybrid cars is a reflection of the widening availability of hybrid models. Figure 5.9 is presented for cars only since the production of hybrid trucks has been limited.

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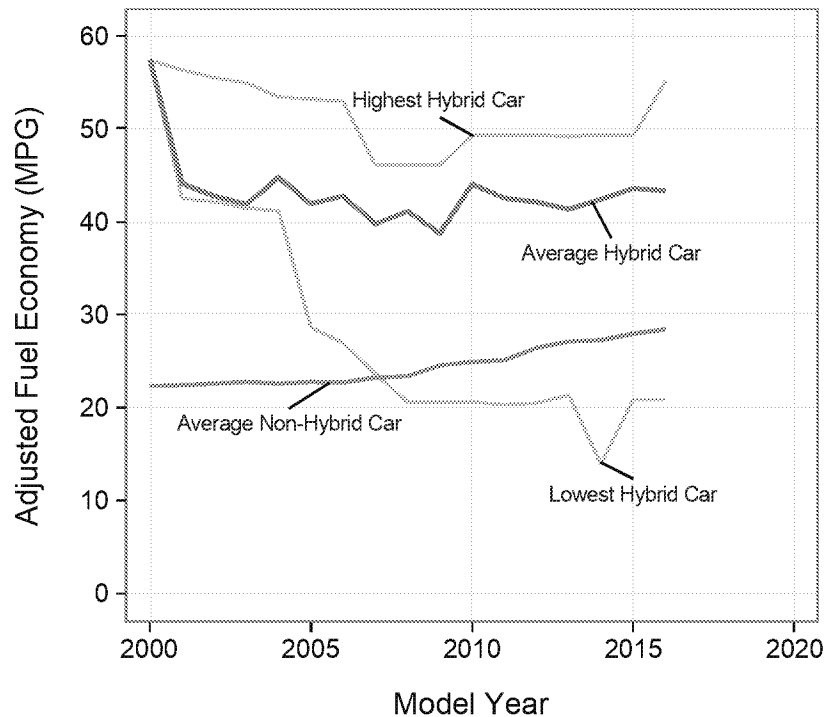
While the average fuel economy of hybrid cars remains higher than the average fuel economy of non-hybrid cars, the difference appears to be narrowing. Average hybrid car fuel economy has been relatively stable since MY 2001, while the fuel economy of the average non-hybrid car has increased more than 27%. Figure 5.10 further explores this trend by examining midsize cars. While generally this report has moved away from using vehicle sub-classes such as midsize sedans, it is a well-established and recognized category and more than 50% of hybrid vehicles are in the midsize car class. Comparing average midsize hybrids to average midsize non-hybrid cars, gasoline only, is an apples-to-apples comparison.

ED_006488A_00003643-00072
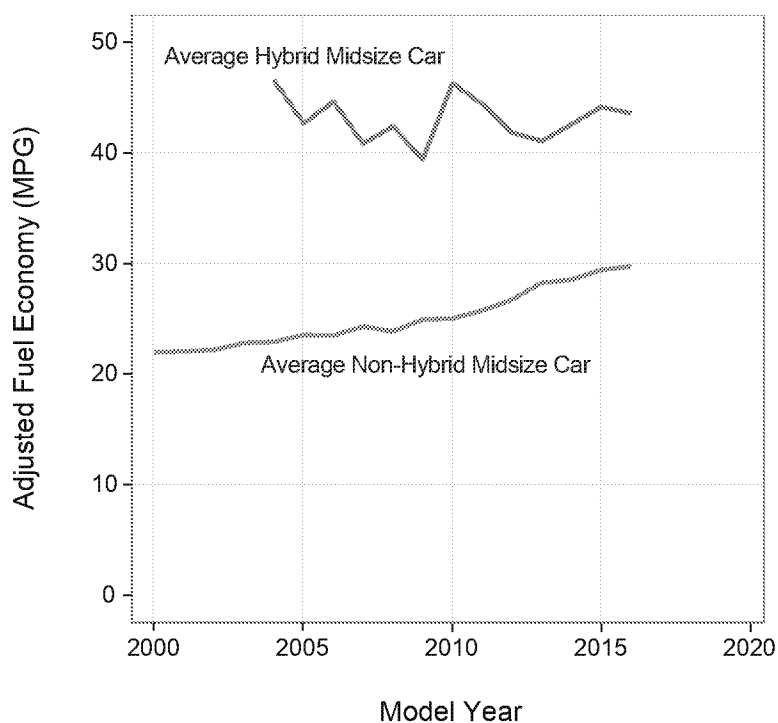
Since MY 2004, the difference in fuel economy between the average hybrid midsize car and the average non-hybrid midsize gasoline car has narrowed from about 25 mpg to about 14 mpg. The primary reason for this trend is continued improvements to the internal combustion engine. Additionally, many technologies introduced or emphasized in early hybrids, such as improved aerodynamics, low rolling resistance tires, and increased use of lightweight materials, have also become more common on non-hybrid vehicles. The lower fuel economy differential between midsize hybrid cars and midsize non-hybrid cars may be one reason why hybrid production share has fluctuated in recent years.

One unique design aspect of hybrids is the ability to use regenerative braking to capture some of the energy lost by a vehicle during braking. The recaptured energy is stored in a battery and is then used to help propel the vehicle, generally during vehicle acceleration. This process results in significantly higher city fuel economy ratings for hybrid vehicles compared to non-hybrid vehicles, and in fact the city fuel economy of many hybrids is typically similar to, if not higher than, their highway fuel economy. Figure 5.11 shows the ratio of highway to city fuel economy for hybrid cars and trucks. Hybrid models have a ratio of highway to city fuel economy near 1.0 (meaning the city and highway fuel economy are nearly equivalent) which is much lower than the 1.4 ratio of highway to city fuel economy for non-hybrid models. This is one aspect of operating a hybrid that is fundamentally different from a conventional vehicle and appears to be relatively steady over time.

Figure 5.11

Highway/City Fuel Economy Ratio for Hybrids and Non-Hybrids, AFVs Excluded
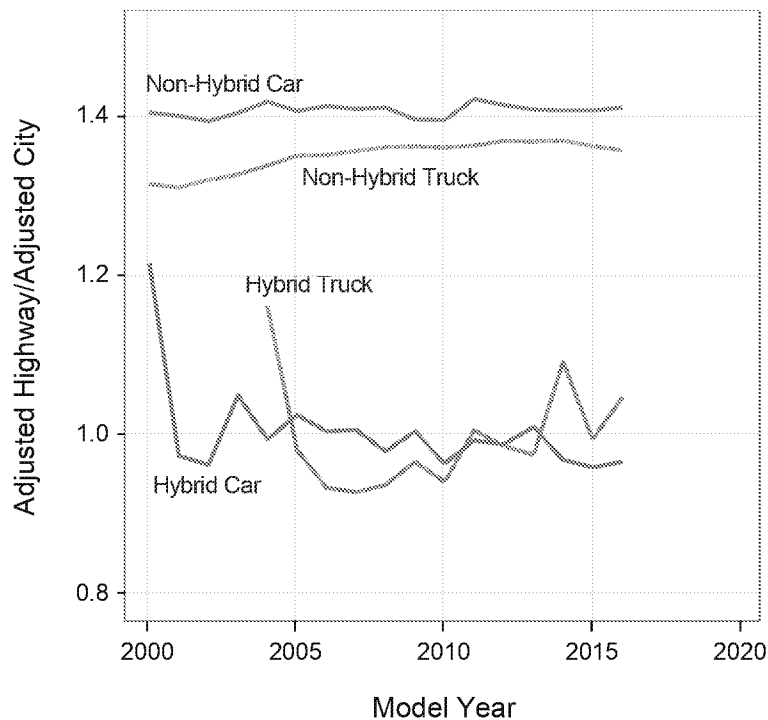
The relationship between hybrids and non-hybrids is clearer if vehicles of the same footprint are compared directly. As shown in Figure 5.12, the fuel consumption of vehicles increases as the footprint increases at about the same rate for both hybrid and non-hybrid vehicles. Hybrids do achieve a higher percentage improvement in smaller vehicles, and achieve more than 30% lower fuel consumption, on average, for vehicles with a footprint of 45 square feet, which is about the size of a standard midsize sedan. The percent improvement figure at the bottom of Figure 5.12 describes the fuel consumption improvement for hybrid vehicles as compared to conventional vehicles over the range of footprints for which both hybrid and conventional vehicles are available. It depicts the percentage difference between the 'best fit' lines for hybrid vehicles and conventional vehicles shown in the upper part of Figure 5.12.

Figure 5.12

Percent Improvement in Adjusted Fuel Consumption for Hybrid Vehicles, MY 2015, AFVs Excluded
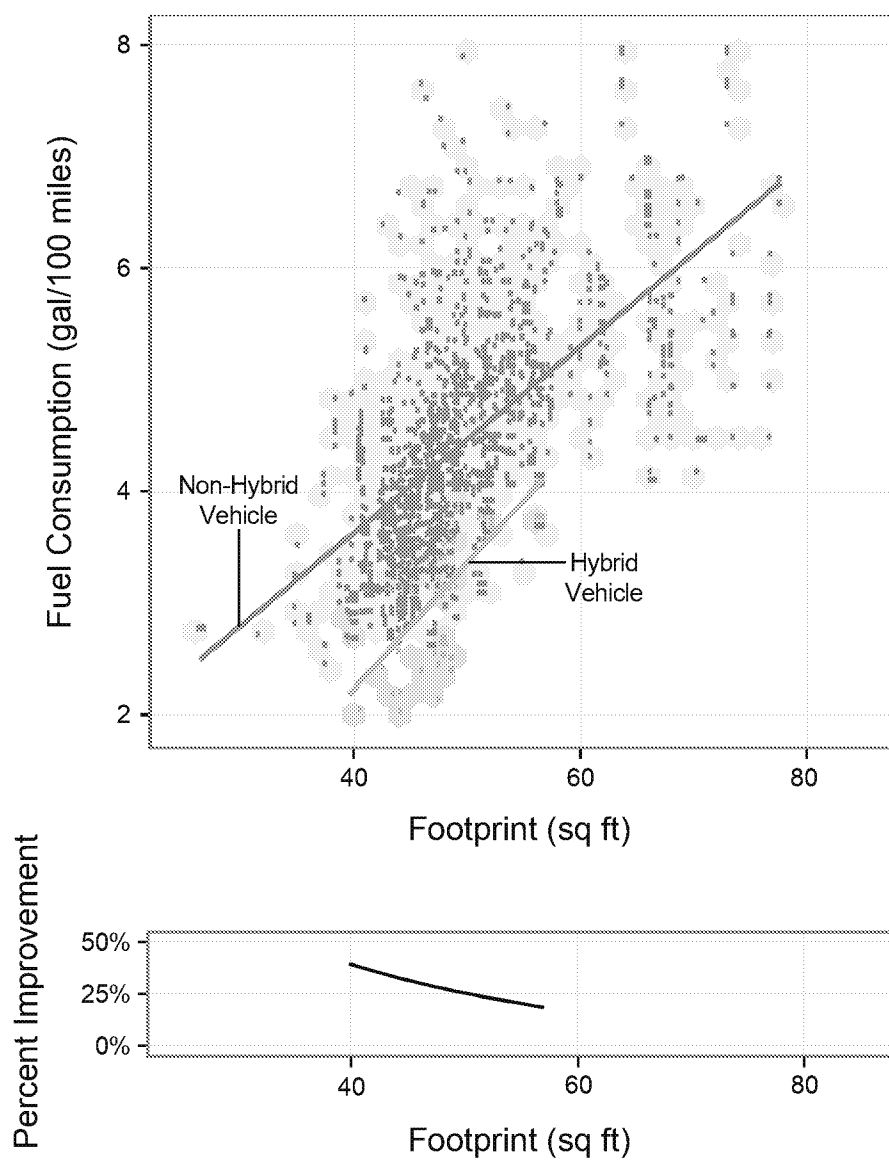
Diesels

Over the last several years, several new diesel vehicles have been introduced in the U.S. market. Production increased in MY 2014 and 2015 to 1% of production, but is projected to fall back to about 0.8% of production in MY 2016. This is the highest penetration of diesel engines since the early 1984, but well below the 5.9% of new vehicles diesel engines reached in 1981. As with hybrid vehicles, diesels generally achieve higher fuel economy than non-diesel vehicles. The relationship between diesel vehicles and all new vehicles is shown in Figure 5.13.

While diesel engines generally achieve higher fuel economy than comparable gasoline vehicles, there is less of an advantage in terms of CO_2 emissions. Some of the fuel economy benefit of diesel engines is negated by the fact that diesel fuel contains about 15% more carbon per gallon, and thus emits more CO_2 per gallon burned than gasoline. Figure 5.14 shows the impact of diesel vehicles on CO_2 emissions by comparing the CO_2 emissions of MY 2015 diesel and gasoline vehicles by footprint.

It is important to note that the Department of Justice, on behalf of EPA, alleged violations of the Clean Air Act by Volkswagen and certain subsidiaries based on the sale of certain MY 2009-2016 diesel vehicles equipped with software designed to cheat on federal emissions tests. In this report, EPA uses the CO_2 emissions and fuel economy data from the initial certification of these vehicles. Should the investigation and corrective actions yield different CO_2 and fuel economy data, the revised data will be used in future reports. For more information on actions to resolve these violations, see www.epa.gov/vw.

Other Technologies

Table 5.3.1 presents comprehensive annual data for the historic MY 1975-2016 database for all of the engine technologies and parameters discussed above and several additional technologies. This report added engine stop/start technology (for non-hybrid vehicles) for the first time last year, and already stop/start technology is projected to be included on nearly 9% of new non-hybrid vehicle production in MY 2016 (note that total use of stop/start is nearly 12% of the market since hybrids typically utilize stop/start as well). Cylinder deactivation, another technology not discussed above, has also grown to capture a projected 9% of production in MY 2016. Tables 5.3.2 and 5.3.3 provide the same data for cars only and trucks only, respectively. This data, and additional data, is further broken down in Appendices E through I.

Figure 5.13

Percent Improvement in Adjusted Fuel Consumption for Diesel Vehicles, MY 2015, AFVs Excluded
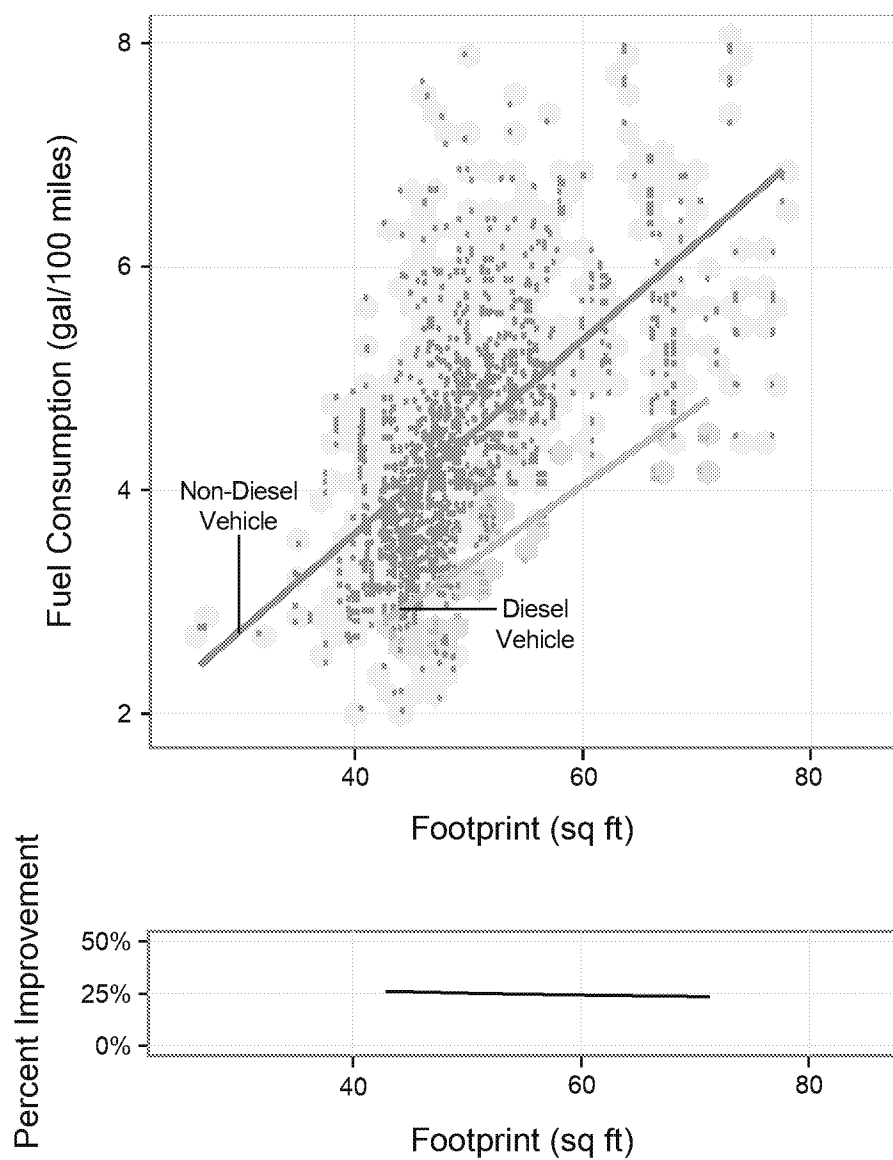
Figure 5.14

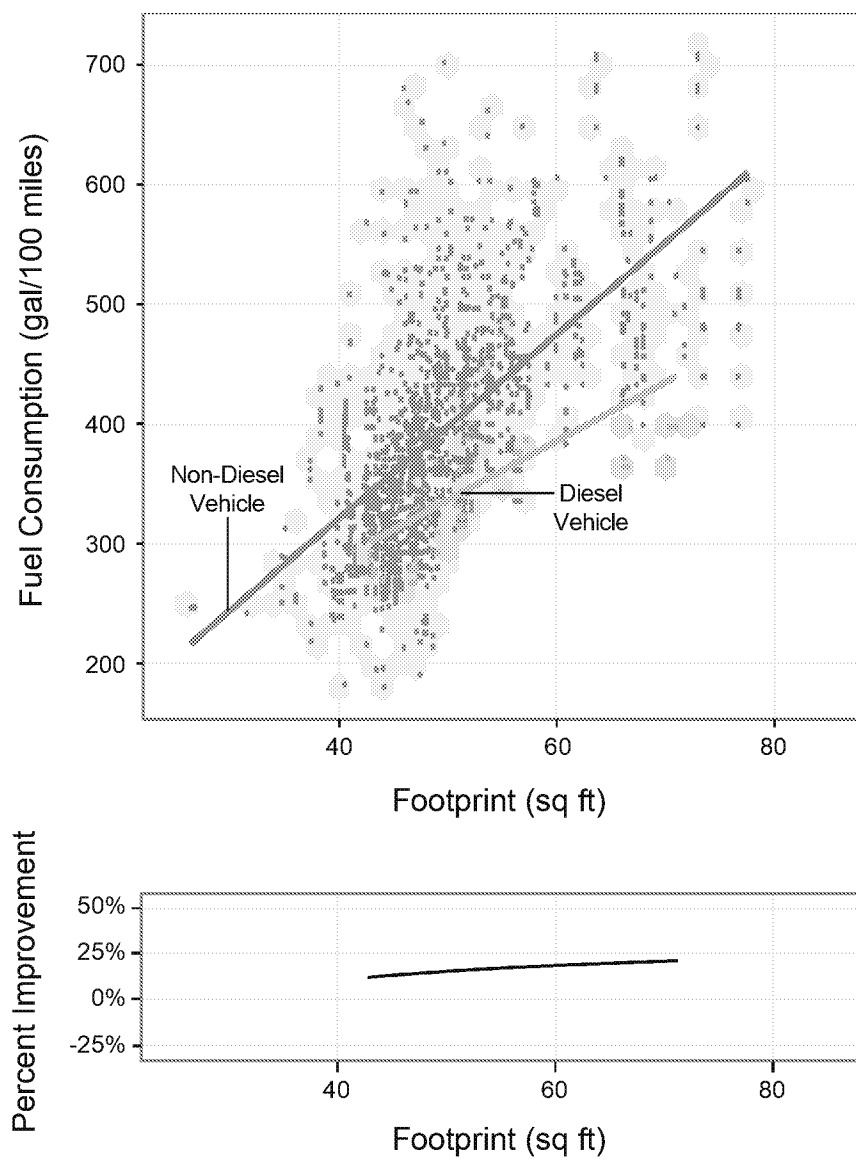*Percent Improvement in CO₂ Emissions for Diesel Vehicles, MY 2015, AFVs Excluded*

Table 5.3.1

Engine Technologies and Parameters, Both Car and Truck, AFVs Excluded

Model Year	Powertrain			Fuel Delivery Method					Avg. No. of Cylinders	CID	HP	Multi-Valve	VVT	CD	Turbo	Stop/Start
	Gasoline	Gasoline Hybrid	Diesel	Carbureted	GDI	Port	TBI	Diesel								
1975	99.8%	-	0.2%	95.7%	-	4.1%	0.0%	0.2%	6.8	293	137	-	-	-	-	-
1976	99.8%	-	0.2%	97.3%	-	2.5%	0.0%	0.2%	6.9	294	135	-	-	-	-	-
1977	99.6%	-	0.4%	96.2%	-	3.4%	0.0%	0.4%	6.9	287	136	-	-	-	-	-
1978	99.1%	-	0.9%	95.2%	-	3.9%	0.0%	0.9%	6.7	266	129	-	-	-	-	-
1979	98.0%	-	2.0%	94.2%	-	3.7%	0.1%	2.0%	6.5	252	124	-	-	-	-	-
1980	95.7%	-	4.3%	89.7%	-	5.2%	0.8%	4.3%	5.6	198	104	-	-	-	-	-
1981	94.1%	-	5.9%	86.7%	-	5.1%	2.4%	5.9%	5.5	193	102	-	-	-	-	-
1982	94.4%	-	5.6%	80.6%	-	5.8%	8.0%	5.6%	5.4	188	103	-	-	-	-	-
1983	97.3%	-	2.7%	75.2%	-	7.3%	14.8%	2.7%	5.5	193	107	-	-	-	-	-
1984	98.2%	-	1.8%	67.6%	-	11.9%	18.7%	1.8%	5.5	190	109	-	-	-	-	-
1985	99.1%	-	0.9%	56.1%	-	18.2%	24.8%	0.9%	5.5	189	114	-	-	-	-	-
1986	99.6%	-	0.4%	41.4%	-	32.5%	25.7%	0.4%	5.3	180	114	3.4%	-	-	-	-
1987	99.7%	-	0.3%	28.4%	-	39.9%	31.4%	0.3%	5.2	175	118	10.6%	-	-	-	-
1988	99.9%	-	0.1%	15.0%	-	50.6%	34.3%	0.1%	5.3	180	123	14.0%	-	-	-	-
1989	99.9%	-	0.1%	8.7%	-	57.3%	33.9%	0.1%	5.4	185	129	16.9%	-	-	-	-
1990	99.9%	-	0.1%	2.1%	-	70.8%	27.0%	0.1%	5.4	185	135	23.1%	-	-	-	-
1991	99.9%	-	0.1%	0.6%	-	70.6%	28.7%	0.1%	5.3	184	138	23.1%	-	-	-	-
1992	99.9%	-	0.1%	0.5%	-	81.6%	17.8%	0.1%	5.5	191	145	23.3%	-	-	-	-
1993	100.0%	-	-	0.3%	-	85.0%	14.6%	-	5.5	191	147	23.5%	-	-	-	-
1994	100.0%	-	0.0%	0.1%	-	87.7%	12.1%	0.0%	5.6	197	152	26.7%	-	-	-	-
1995	100.0%	-	0.0%	-	-	91.6%	8.4%	0.0%	5.6	196	158	35.6%	-	-	-	-
1996	99.9%	-	0.1%	-	-	99.3%	0.7%	0.1%	5.6	197	164	39.3%	-	-	0.2%	-
1997	99.9%	-	0.1%	-	-	99.5%	0.5%	0.1%	5.7	199	169	39.6%	-	-	0.4%	-
1998	99.9%	-	0.1%	-	-	99.8%	0.1%	0.1%	5.6	199	171	40.9%	-	-	0.8%	-
1999	99.9%	-	0.1%	-	-	99.9%	0.1%	0.1%	5.8	203	179	43.4%	-	-	1.4%	-
2000	99.8%	0.0%	0.1%	-	-	99.8%	0.0%	0.1%	5.7	200	181	44.8%	15.0%	-	1.3%	-
2001	99.7%	0.1%	0.1%	-	-	99.9%	-	0.1%	5.8	201	187	49.0%	19.6%	-	2.0%	-
2002	99.6%	0.2%	0.2%	-	-	99.8%	-	0.2%	5.8	203	195	53.3%	25.3%	-	2.2%	-
2003	99.5%	0.3%	0.2%	-	-	99.8%	-	0.2%	5.8	204	199	55.5%	30.6%	-	1.2%	-
2004	99.4%	0.5%	0.1%	-	-	99.9%	-	0.1%	5.9	212	211	62.3%	38.5%	-	2.3%	-
2005	98.6%	1.1%	0.3%	-	-	99.7%	-	0.3%	5.8	205	209	65.6%	45.8%	0.8%	1.7%	-
2006	98.1%	1.5%	0.4%	-	-	99.6%	-	0.4%	5.7	204	213	71.7%	55.4%	3.6%	2.1%	-
2007	97.7%	2.2%	0.1%	-	-	99.8%	-	0.1%	5.6	203	217	71.7%	57.3%	7.3%	2.5%	-
2008	97.4%	2.5%	0.1%	-	2.3%	97.6%	-	0.1%	5.6	199	219	76.4%	58.2%	6.7%	3.0%	-
2009	97.2%	2.3%	0.5%	-	4.2%	95.2%	-	0.5%	5.2	183	208	83.8%	71.5%	7.3%	3.3%	-
2010	95.5%	3.8%	0.7%	-	8.3%	91.0%	-	0.7%	5.3	188	214	85.5%	83.8%	6.4%	3.3%	-
2011	97.1%	2.2%	0.8%	-	15.4%	83.8%	-	0.8%	5.4	192	230	86.4%	93.1%	9.5%	6.8%	-
2012	95.9%	3.1%	0.9%	-	22.6%	76.5%	-	0.9%	5.1	181	222	91.9%	96.7%	8.1%	8.4%	0.6%
2013	95.5%	3.6%	0.9%	-	30.7%	68.4%	-	0.9%	5.1	176	226	93.1%	97.7%	7.7%	14.0%	2.3%
2014	96.3%	2.6%	1.0%	-	37.7%	61.3%	-	1.0%	5.1	180	231	89.4%	97.9%	10.7%	14.9%	5.1%
2015	96.6%	2.4%	1.0%	-	42.2%	56.9%	-	1.0%	5.0	177	229	91.6%	97.7%	10.6%	15.8%	7.2%
2016 (prelim)	96.7%	2.6%	0.8%	-	48.5%	50.8%	-	0.8%	4.9	170	228	92.8%	96.8%	8.9%	22.3%	9.2%

Table 5.3.2

Engine Technologies and Parameters, Car Only, AFVs Excluded

Model Year	Powertrain			Fuel Delivery Method					Avg. No. of Cylinders	CID	HP	Multi-Valve	VVT	CD	Turbo	Stop/Start
	Gasoline	Gasoline Hybrid	Diesel	Carbureted	GDI	Port	TBI	Diesel								
1975	99.8%	-	0.2%	94.6%	-	5.1%	-	0.2%	6.7	288	136	-	-	-	-	-
1976	99.7%	-	0.3%	96.6%	-	3.2%	-	0.3%	6.8	287	134	-	-	-	-	-
1977	99.5%	-	0.5%	95.3%	-	4.2%	-	0.5%	6.9	279	133	-	-	-	-	-
1978	99.1%	-	0.9%	94.0%	-	5.1%	-	0.9%	6.5	251	124	-	-	-	-	-
1979	97.9%	-	2.1%	93.2%	-	4.7%	-	2.1%	6.4	238	119	-	-	-	-	-
1980	95.6%	-	4.4%	88.7%	-	6.2%	0.7%	4.4%	5.5	188	100	-	-	-	-	-
1981	94.1%	-	5.9%	85.3%	-	6.1%	2.6%	5.9%	5.4	182	99	-	-	-	-	-
1982	95.3%	-	4.7%	78.4%	-	7.2%	9.8%	4.7%	5.2	175	99	-	-	-	-	-
1983	97.9%	-	2.1%	69.7%	-	9.4%	18.8%	2.1%	5.4	182	104	-	-	-	-	-
1984	98.3%	-	1.7%	59.1%	-	14.9%	24.3%	1.7%	5.3	179	106	-	-	-	-	-
1985	99.1%	-	0.9%	46.0%	-	21.3%	31.8%	0.9%	5.3	177	111	-	-	-	-	-
1986	99.7%	-	0.3%	34.4%	-	36.5%	28.7%	0.3%	5.1	167	111	4.7%	-	-	-	-
1987	99.8%	-	0.2%	26.5%	-	42.4%	30.8%	0.2%	5.0	162	113	14.6%	-	-	-	-
1988	100.0%	-	0.0%	16.1%	-	53.7%	30.2%	0.0%	5.0	161	116	19.7%	-	-	-	-
1989	100.0%	-	0.0%	9.6%	-	62.2%	28.1%	0.0%	5.1	163	121	24.1%	-	-	-	-
1990	100.0%	-	0.0%	1.4%	-	77.4%	21.2%	0.0%	5.1	163	129	32.8%	0.6%	-	-	-
1991	99.9%	-	0.1%	0.1%	-	77.2%	22.6%	0.1%	5.1	164	133	33.2%	2.4%	-	-	-
1992	99.9%	-	0.1%	0.0%	-	88.9%	11.0%	0.1%	5.2	171	141	34.0%	4.4%	-	-	-
1993	100.0%	-	-	0.0%	-	91.5%	8.5%	-	5.2	170	140	34.8%	4.5%	-	-	-
1994	100.0%	-	0.0%	-	-	94.8%	5.2%	0.0%	5.2	169	144	39.9%	7.7%	-	-	-
1995	99.9%	-	0.1%	-	-	98.6%	1.3%	0.1%	5.2	168	153	51.4%	9.6%	-	-	-
1996	99.9%	-	0.1%	-	-	98.8%	1.1%	0.1%	5.2	167	155	56.4%	11.3%	-	0.3%	-
1997	99.9%	-	0.1%	-	-	99.2%	0.8%	0.1%	5.1	165	156	58.4%	10.8%	-	0.7%	-
1998	99.8%	-	0.2%	-	-	99.7%	0.1%	0.2%	5.2	167	160	59.6%	17.4%	-	1.4%	-
1999	99.8%	-	0.2%	-	-	99.8%	0.1%	0.2%	5.2	168	164	63.2%	16.4%	-	2.5%	-
2000	99.7%	0.1%	0.2%	-	-	99.7%	0.1%	0.2%	5.2	168	168	63.2%	22.2%	-	2.2%	-
2001	99.5%	0.2%	0.2%	-	-	99.8%	-	0.2%	5.2	167	169	65.3%	26.9%	-	3.3%	-
2002	99.3%	0.3%	0.4%	-	-	99.6%	-	0.4%	5.1	167	173	69.9%	32.8%	-	3.9%	-
2003	99.1%	0.6%	0.3%	-	-	99.7%	-	0.3%	5.1	166	176	73.4%	39.8%	-	2.0%	-
2004	98.9%	0.9%	0.3%	-	-	99.7%	-	0.3%	5.2	170	184	77.1%	43.7%	-	3.6%	-
2005	97.6%	1.9%	0.4%	-	-	99.6%	-	0.4%	5.1	168	183	77.2%	49.4%	1.0%	2.4%	-
2006	97.9%	1.5%	0.6%	-	-	99.4%	-	0.6%	5.2	173	194	81.3%	58.2%	2.0%	3.2%	-
2007	96.7%	3.2%	0.0%	-	-	99.7%	-	0.0%	5.0	167	191	84.6%	63.3%	0.9%	3.6%	-
2008	96.7%	3.3%	0.1%	-	3.1%	96.9%	-	0.1%	5.0	166	194	88.0%	62.7%	2.0%	4.5%	-
2009	96.4%	2.9%	0.6%	-	4.2%	95.2%	-	0.6%	4.7	157	186	92.2%	79.1%	1.8%	4.0%	-
2010	93.5%	5.6%	0.9%	-	9.2%	89.9%	-	0.9%	4.7	158	190	93.8%	91.8%	2.1%	4.1%	-
2011	95.6%	3.4%	0.9%	-	18.4%	80.7%	-	0.9%	4.7	161	200	94.6%	94.9%	1.3%	8.2%	-
2012	94.3%	4.7%	1.0%	-	27.6%	71.4%	-	1.0%	4.6	151	192	98.2%	97.7%	1.7%	9.7%	0.9%
2013	93.5%	5.4%	1.1%	-	37.7%	61.2%	-	1.1%	4.5	147	197	98.5%	98.1%	1.9%	15.3%	3.0%
2014	94.5%	4.2%	1.3%	-	43.2%	55.5%	-	1.3%	4.5	148	198	98.1%	97.9%	2.2%	18.4%	6.8%
2015	95.1%	4.0%	0.8%	-	44.6%	54.6%	-	0.8%	4.4	146	197	98.4%	98.5%	2.2%	18.3%	8.3%
2016 (prelim)	*96.3%*	*3.6%*	*0.1%*	-	*51.6%*	*48.3%*	-	*0.1%*	*4.4*	*144*	*199*	*96.3%*	*97.4%*	*2.3%*	*25.2%*	*8.3%*

Table 5.3.3

Engine Technologies and Parameters, Truck Only, AFVs Excluded

Model Year	Powertrain			Fuel Delivery Method					Avg. No. of Cylinders	CID	HP	Multi-Valve	VVT	CD	Turbo	Stop/Start
	Gasoline	Gasoline Hybrid	Diesel	Carbureted	GDI	Port	TBI	Diesel								
1975	100.0%	-	-	99.9%	-	-	0.1%	-	7.3	311	142	-	-	-	-	-
1976	100.0%	-	-	99.9%	-	-	0.1%	-	7.3	320	141	-	-	-	-	-
1977	100.0%	-	-	99.9%	-	-	0.1%	-	7.3	318	147	-	-	-	-	-
1978	99.2%	-	0.8%	99.1%	-	-	0.1%	0.8%	7.3	315	146	-	-	-	-	-
1979	98.2%	-	1.8%	97.9%	-	-	0.3%	1.8%	7.1	299	138	-	-	-	-	-
1980	96.5%	-	3.5%	94.9%	-	-	1.7%	3.5%	6.2	248	121	-	-	-	-	-
1981	94.4%	-	5.6%	93.3%	-	-	1.1%	5.6%	6.2	247	119	-	-	-	-	-
1982	90.6%	-	9.4%	89.9%	-	-	0.7%	9.4%	6.3	244	120	-	-	-	-	-
1983	95.2%	-	4.8%	94.6%	-	-	0.6%	4.8%	6.1	232	118	-	-	-	-	-
1984	97.6%	-	2.4%	95.0%	-	2.0%	0.6%	2.4%	6.0	225	118	-	-	-	-	-
1985	98.9%	-	1.1%	86.5%	-	8.9%	3.5%	1.1%	6.0	225	124	-	-	-	-	-
1986	99.3%	-	0.7%	59.4%	-	22.1%	17.8%	0.7%	5.7	212	123	-	-	-	-	-
1987	99.7%	-	0.3%	33.6%	-	33.3%	32.8%	0.3%	5.7	211	131	-	-	-	-	-
1988	99.8%	-	0.2%	12.4%	-	43.2%	44.3%	0.2%	6.0	228	141	-	-	-	-	-
1989	99.8%	-	0.2%	6.5%	-	45.9%	47.5%	0.2%	6.0	234	146	-	-	-	-	-
1990	99.8%	-	0.2%	3.8%	-	55.0%	40.9%	0.2%	6.2	237	151	-	-	-	-	-
1991	99.9%	-	0.1%	1.7%	-	55.3%	42.8%	0.1%	6.0	229	150	-	-	-	-	-
1992	99.9%	-	0.1%	1.6%	-	65.7%	32.6%	0.1%	6.1	236	155	-	-	-	-	-
1993	100.0%	-	-	1.0%	-	71.5%	27.5%	-	6.1	235	160	-	-	-	-	-
1994	100.0%	-	-	0.4%	-	76.2%	23.4%	-	6.2	241	166	5.2%	-	-	-	-
1995	100.0%	-	-	-	-	79.4%	20.6%	-	6.2	245	168	8.0%	-	-	-	-
1996	99.9%	-	0.1%	-	-	99.9%	-	0.1%	6.3	245	179	11.2%	-	-	-	-
1997	100.0%	-	0.0%	-	-	100.0%	-	0.0%	6.5	251	189	11.1%	-	-	-	-
1998	100.0%	-	0.0%	-	-	100.0%	-	0.0%	6.3	244	188	14.8%	-	-	-	-
1999	100.0%	-	0.0%	-	-	100.0%	-	0.0%	6.5	252	199	15.7%	-	-	-	-
2000	100.0%	-	-	-	-	100.0%	-	-	6.5	245	199	18.6%	4.6%	-	-	-
2001	100.0%	-	-	-	-	100.0%	-	-	6.6	249	212	25.9%	9.3%	-	-	-
2002	100.0%	-	-	-	-	100.0%	-	-	6.6	249	223	32.8%	16.0%	-	-	-
2003	100.0%	-	-	-	-	100.0%	-	-	6.6	248	224	34.6%	19.7%	-	0.2%	-
2004	100.0%	0.0%	0.0%	-	-	100.0%	-	0.0%	6.7	258	240	46.2%	32.9%	-	0.8%	-
2005	99.8%	0.1%	0.1%	-	-	99.9%	-	0.1%	6.6	251	242	51.1%	41.2%	0.5%	0.7%	-
2006	98.4%	1.5%	0.1%	-	-	99.9%	-	0.1%	6.5	247	240	58.4%	51.5%	5.9%	0.6%	-
2007	99.1%	0.8%	0.1%	-	-	99.9%	-	0.1%	6.6	253	254	53.3%	48.7%	16.4%	1.0%	-
2008	98.5%	1.3%	0.2%	-	1.1%	98.7%	-	0.2%	6.4	246	254	59.5%	51.6%	13.5%	1.0%	-
2009	98.8%	0.9%	0.3%	-	4.2%	95.4%	-	0.3%	6.2	236	252	66.7%	56.0%	18.3%	1.7%	-
2010	98.8%	0.9%	0.4%	-	6.8%	92.9%	-	0.4%	6.2	237	253	71.5%	70.5%	13.8%	1.8%	-
2011	99.1%	0.4%	0.5%	-	11.3%	88.1%	-	0.5%	6.2	236	271	75.2%	90.7%	20.6%	4.9%	-
2012	98.9%	0.4%	0.7%	-	13.5%	85.8%	-	0.7%	6.2	234	276	80.6%	94.9%	19.6%	6.1%	0.2%
2013	99.1%	0.4%	0.5%	-	18.4%	81.1%	-	0.5%	6.1	228	277	83.5%	96.9%	18.0%	11.7%	1.1%
2014	99.0%	0.4%	0.6%	-	29.7%	69.6%	-	0.6%	6.0	227	277	76.9%	98.0%	22.9%	9.9%	2.5%
2015	98.6%	0.3%	1.1%	-	39.0%	59.9%	-	1.1%	5.9	218	271	82.7%	96.7%	21.7%	12.6%	5.6%
2016	*97.3%*	*0.9%*	*1.8%*	-	*43.5%*	*54.8%*	-	*1.8%*	*5.8*	*211*	*273*	*87.2%*	*95.7%*	*19.5%*	*17.6%*	*10.6%*

C. Trends in Alternative Fuel Vehicles

Alternative fuel vehicles have a long history in the U.S. automotive market. Electric vehicles, for example, were available at least as far back as the early 1900s. Gasoline and diesel vehicles, however, have long dominated new light vehicles sales. Over the course of this report, OEM vehicles that operate frequently on alternative fuels have been available only in small numbers,[5] though those limited production vehicles have in some cases created significant consumer and media interest. AFVs are projected to surpass 1% of production in MY 2016 (see Table 5.1), though we will not have final production data until next year's report.

As shown in Figure 5.15, the production of AFVs has increased dramatically in recent years. Prior to MY 2011, the AFVs available to consumers were only available in small numbers, and generally only as lease vehicles. The AFV market began to change in MY 2011, with the introduction of several new vehicles, including the high profile launches of the Chevrolet Volt plug in hybrid electric vehicle (PHEV) and the Nissan Leaf electric vehicle (EV). In MY 2016, there are now 14 PHEVs available, and 12 EVs, 2 fuel cell vehicles, and one dual fuel natural gas vehicle. Dedicated CNG vehicles have been available from at least one OEM with some regularity, but have never sold more than a few thousand vehicles in any year. Figure 5.15 shows the historical sales of EVs, PHEVs, and dedicated CNG vehicles since 1995 (we do not have reliable data on alternative fuel vehicles back to 1975).

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[5] Millions of ethanol FFVs have been sold in recent years, but these vehicles have operated primarily on gasoline.

Figure 5.15

Historical Production of EVs, PHEVs, FCVs, and CNG Vehicles, MY 1995–2015
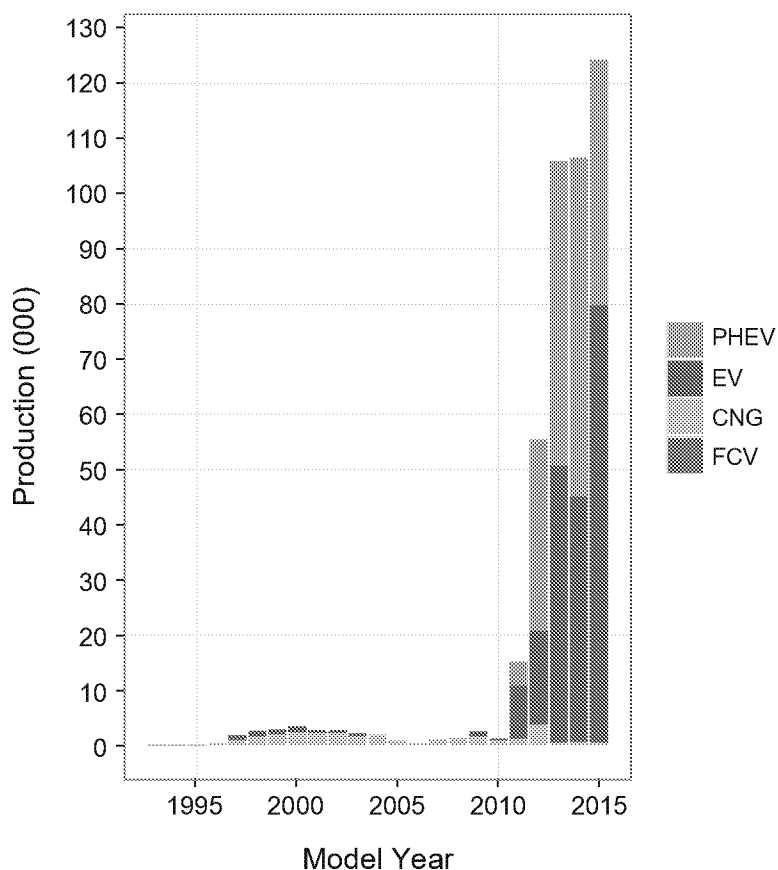
Consistent with the rest of this report, Figure 5.15 was largely compiled from manufacturer CAFE submissions. Some of the historical production data was supplemented with data from Ward's and other publically available production data. Figure 5.15 includes dedicated CNG vehicles, but not dual fuel CNG vehicles as sales data were not available for dual fuel vehicles. The data only includes offerings from OEMs, and does not include data on vehicles converted to alternative fuels in the aftermarket. For a more detailed description of individual AFVs and the parameters used to measure fuel economy and emissions, see section 7.

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D. TRENDS IN TRANSMISSION TYPES

Transmission technologies have been rapidly evolving in new light duty vehicles. New transmission technologies have been gaining market share, and nearly all transmission types have been increasing the number of gears. Dual clutch transmission (DCTs), continuously variable transmissions (CVTs), and automatic transmissions with greater numbers of gears are increasing production shares across the fleet. This section presents analysis of trends in transmission technologies, including AFVs.

Figure 5.16 shows the evolution of transmission production share for cars and trucks since MY 1980. For this analysis, transmissions are separated into manual transmissions, CVTs, and automatic transmissions. Automatic transmissions are further separated into those with and without lockup mechanisms, which can lock up the torque converter in an automatic transmission under certain driving conditions and improve efficiency. CVT transmissions have also been split into hybrid and non-hybrid versions to reflect the fact that hybrid CVT transmissions are generally very different mechanically from traditional CVT transmissions.

Dual clutch transmissions (DCTs) are essentially automatic transmissions that operate internally much more like traditional manual transmissions. The two main advantages of DCTs are that they can shift very quickly and they can avoid some of the internal resistance of a traditional automatic transmission by eliminating the torque converter. Currently, automaker submissions to EPA do not explicitly identify DCTs as a separate transmission category. Thus, the introduction of DCTs shows up in Tables 5.4.1 through 5.4.3 as a slight increase in automatic transmissions without torque converters (although some DCTs may still be reported as traditional automatic transmissions). EPA's long-term goal is to improve DCT data collection, and transmission classifications in general, to be able to quantify DCTs in future Trends reports.

Figure 5.16 shows transmission production share for the individual car and truck fleets, beginning with MY 1980, because EPA has incomplete data on the number of transmission gears for MY 1975 through 1978. In the early 1980s, 3 speed automatic transmissions, both with and without lockup torque converters (shown as L3 and A3 in Figure 5.16) were the most popular transmissions, but by MY 1985, the 4 speed automatic transmission with lockup (L4) became the most popular transmission, a position it would hold for 25 years. Over 80% of all new vehicles produced in MY 1999 were equipped with an L4 transmission. After MY 1999, the production share of L4 transmissions slowly decreased as L5 and L6 transmissions were introduced into the market. Production of L5 and L6 transmissions combined passed the production of L4 transmissions in MY 2007. Interestingly, 5 speed transmissions were never the leading transmission technology in terms of production share.

Figure 5.16

Transmission Production Share

Transmission	Lockup?	Number of Gears	Key
Automatic	No	3	A3
Semi-Automatic		4	A4
Automated Manual		5	A5
		6	A6
		7	A7
	Yes	2	L2
		3	L3
		4	L4
		5	L5
		6	L6
		7	L7
		8	L8
		9	L9
Manual	—	3	M3
		4	M4
		5	M5
		6	M6
		7	M7
Continuously Variable (non-hybrid)	—	—	CVT(n-h)
Continuously Variable (hybrid)	—	—	CVT(h)
Other	—	—	Other
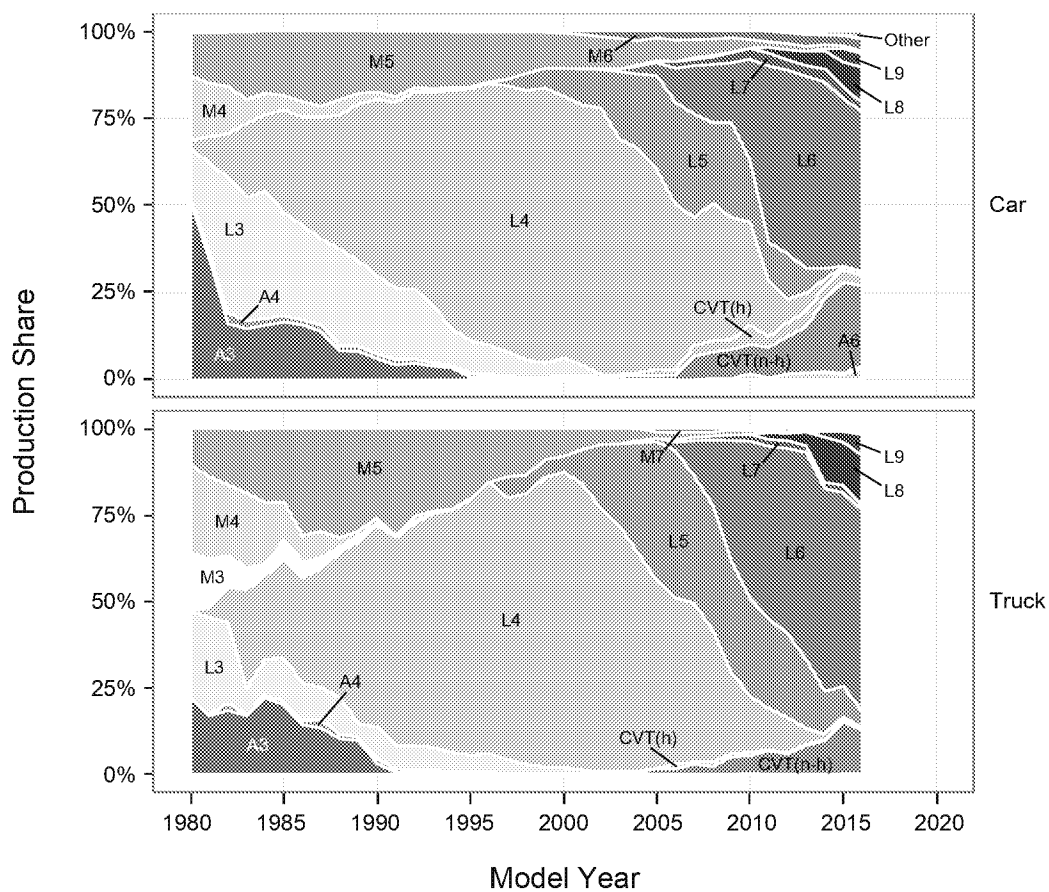
Six speed transmissions became the most popular transmission choice in MY 2010 and reached 60% of new vehicle production in MY 2013. However, six speed transmissions may already have peaked, as transmissions with more than six speeds and CVTs have begun to expand quickly. CVTs are projected to be installed in over 20% of all new vehicles in MY 2016 (including hybrids). This is a significant increase considering that, as recently as MY 2006, CVTs were installed on less than 3% of vehicles produced. Transmissions with 7 or more speeds are projected to be installed in almost 20% of vehicles in MY 2016, and are also quickly increasing. Manufacturers are publicly discussing the development of transmissions with as many as 10 or more gears, so this is a trend that the authors also expect to continue.

Figure 5.17 shows the average number of gears in new vehicle transmissions since MY 1980 for automatic and manual transmissions. During that time, the average number of gears in a new vehicle has grown from 3.5 to a projected level of 6.0 in MY 2016. The average number of gears in new vehicles is climbing for car, trucks, automatic transmissions, and manual transmissions.

Figure 5.17
Average Number of Transmission Gears for New Vehicles
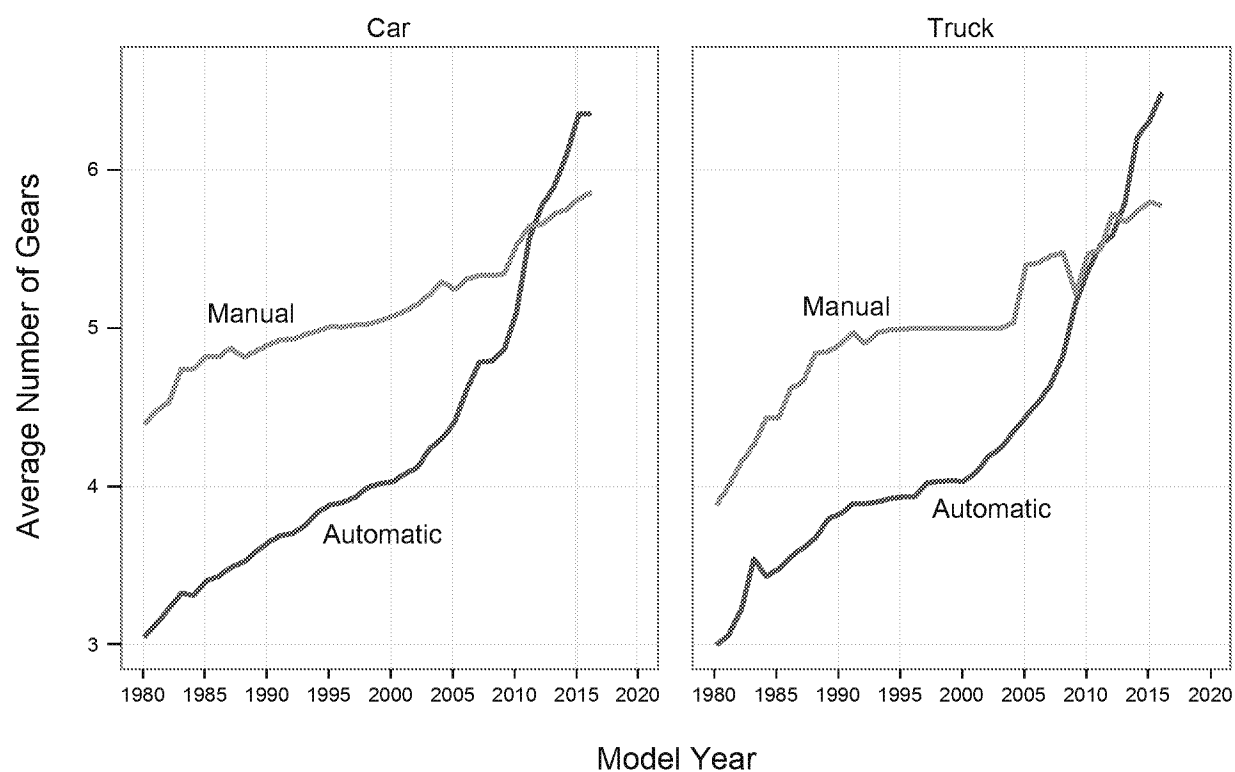
In MY 1980, automatic transmissions, on average, had fewer gears than manual transmissions. However, automatic transmissions have added gears faster than manual transmissions and now the average automatic transmission has more gears than the average manual transmission. There has also been a large shift away from manual transmissions. Manual transmission production peaked in MY 1980 at nearly 35% of production, and has since fallen to 2.6% in MY 2015. Today, manual transmissions are used primarily in small vehicles, some sports cars, and a few pickups.

In the past, automatic transmissions have generally been less efficient than manual transmissions, largely due to inefficiencies in the automatic transmission torque converter. Figure 5.18 examines this trend over time by comparing the fuel economy of automatic and manual transmission options where both transmissions were available in one model with the same engine. The average fuel economy of vehicles with automatic transmissions appears to have increased to a point where it is now slightly higher than the average fuel economy of vehicles with manual transmissions. Two contributing factors to this trend are that automatic transmission design has become more efficient (using earlier lockup and other strategies), and the number of gears used in automatic transmissions has increased faster than in manual transmissions.

Figure 5.18

Comparison of Manual and Automatic Transmission Adjusted Fuel Economy
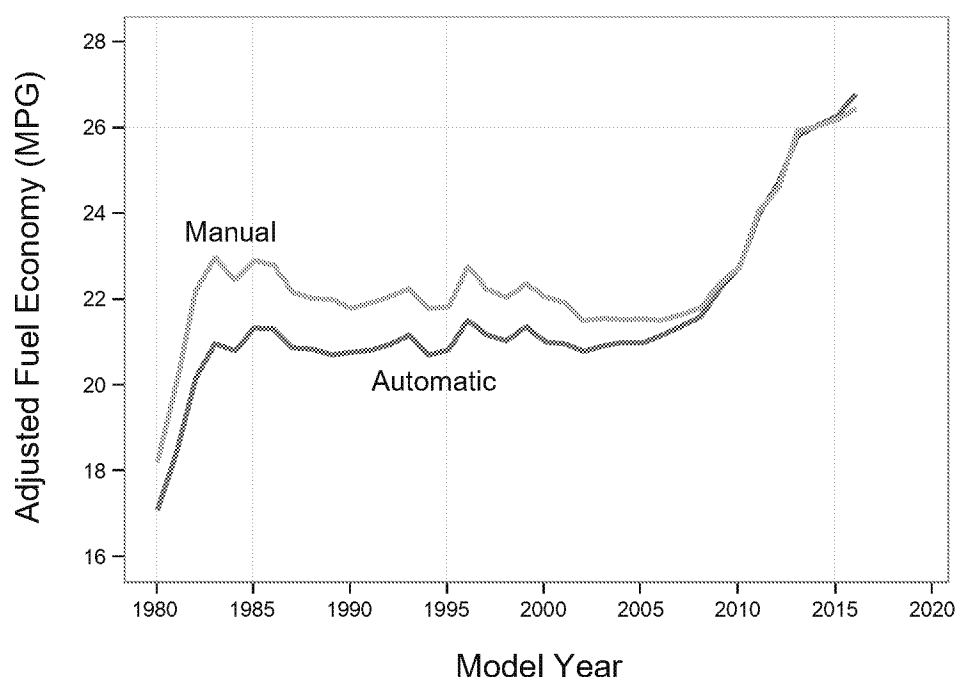
E. TRENDS IN DRIVE TYPES

There has been a long and steady trend in new vehicle drive type away from rear wheel drive vehicles towards front wheel drive and four wheel drive vehicles, as shown in Figure 5.19. In MY 1975, over 91% of new vehicles were produced with rear wheel drive. During the 1980s, production of rear wheel drive vehicles fell rapidly, to 26% in MY 1990. Since then, production of rear wheel drive vehicles has continued to decline, albeit at a slower rate, to a projected 11% for MY 2016. Current production of rear wheel drive vehicles is mostly limited to pickup trucks and some performance vehicles.

As production of rear wheel drive vehicles declined, production of front wheel drive vehicles increased. Front wheel drive vehicle production was only 5.3% of new vehicle production in MY 1975, but it became the most popular drive technology across new vehicles in MY 1985, and has remained so to date. Since MY 1986, production of front wheel drive vehicles has remained, on average, at approximately 55% of production.

Four wheel drive vehicles (including all wheel drive), have slowly but steadily grown across new vehicle production. From 3.3% in MY 1975 to a projected 34% in MY 2016, four wheel drive production has steadily grown at approximately 0.6% per year, on average. The majority of four wheel drive vehicles are pickup trucks and truck SUVs, but there is also a small but slowly growing number of cars featuring four wheel drive (or more likely) all-wheel drive systems.

Figure 5.19

Front, Rear, and Four Wheel Drive Usage - Production Share by Vehicle Type
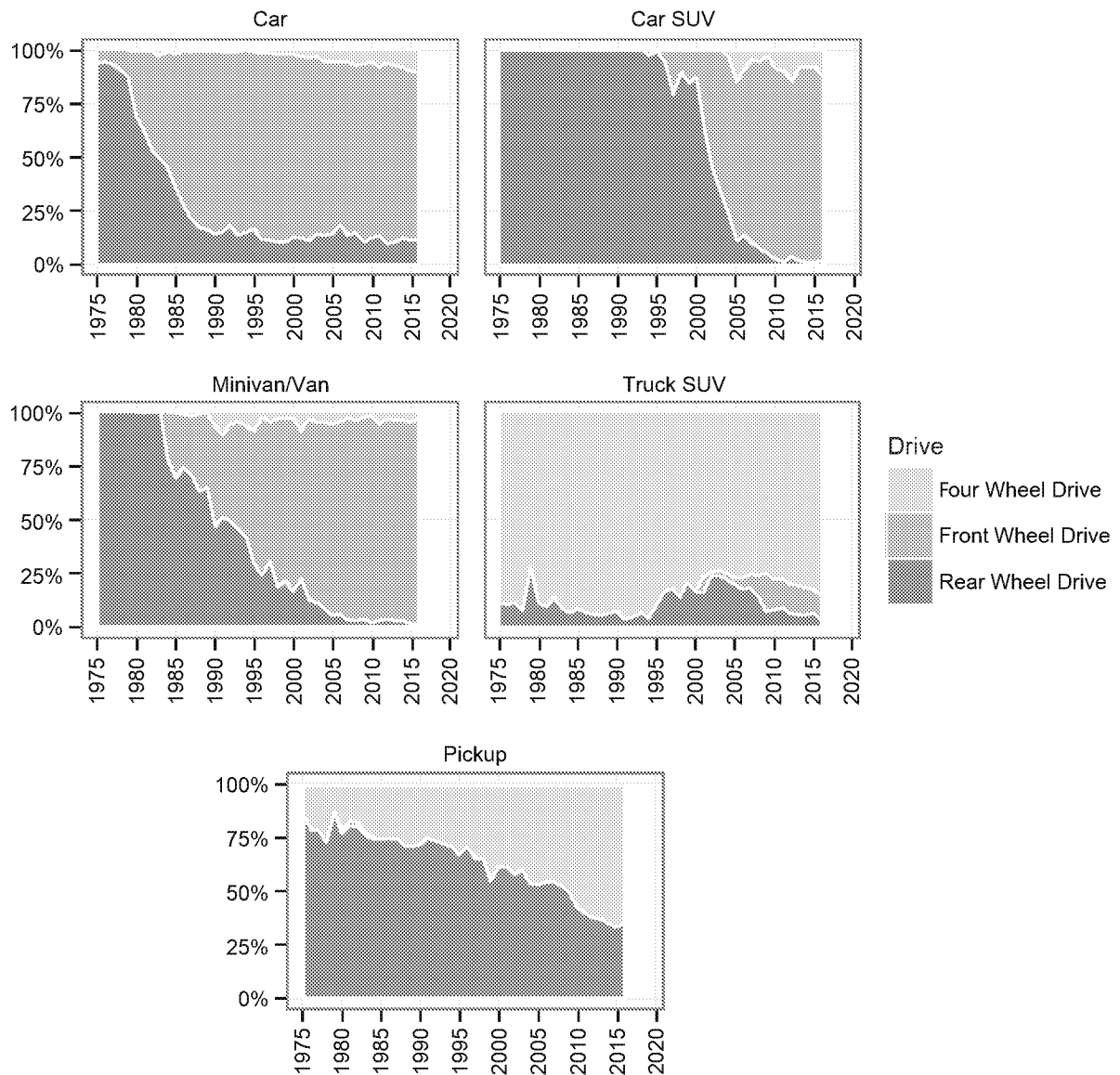
There are noticeable differences in fuel economy between vehicles with different drive types. Figure 5.20 shows the fuel consumption of MY 2015 vehicles separated by drive type and footprint. Rear wheel drive vehicles and four wheel drive vehicles have on average the same fuel consumption for equivalent footprint vehicles. Front wheel drive vehicles have much lower fuel consumption than rear wheel drive or four wheel drive vehicles of the same footprint. For 45 square foot vehicles, front wheel drive vehicles have fuel consumption about 20% lower. There are certainly other factors involved (rear wheel drive vehicles are likely more performance oriented, for example), but this is a noticeable trend across new vehicle production. The points in Figure 5.20 are generated for each combination of adjusted fuel consumption and footprint.
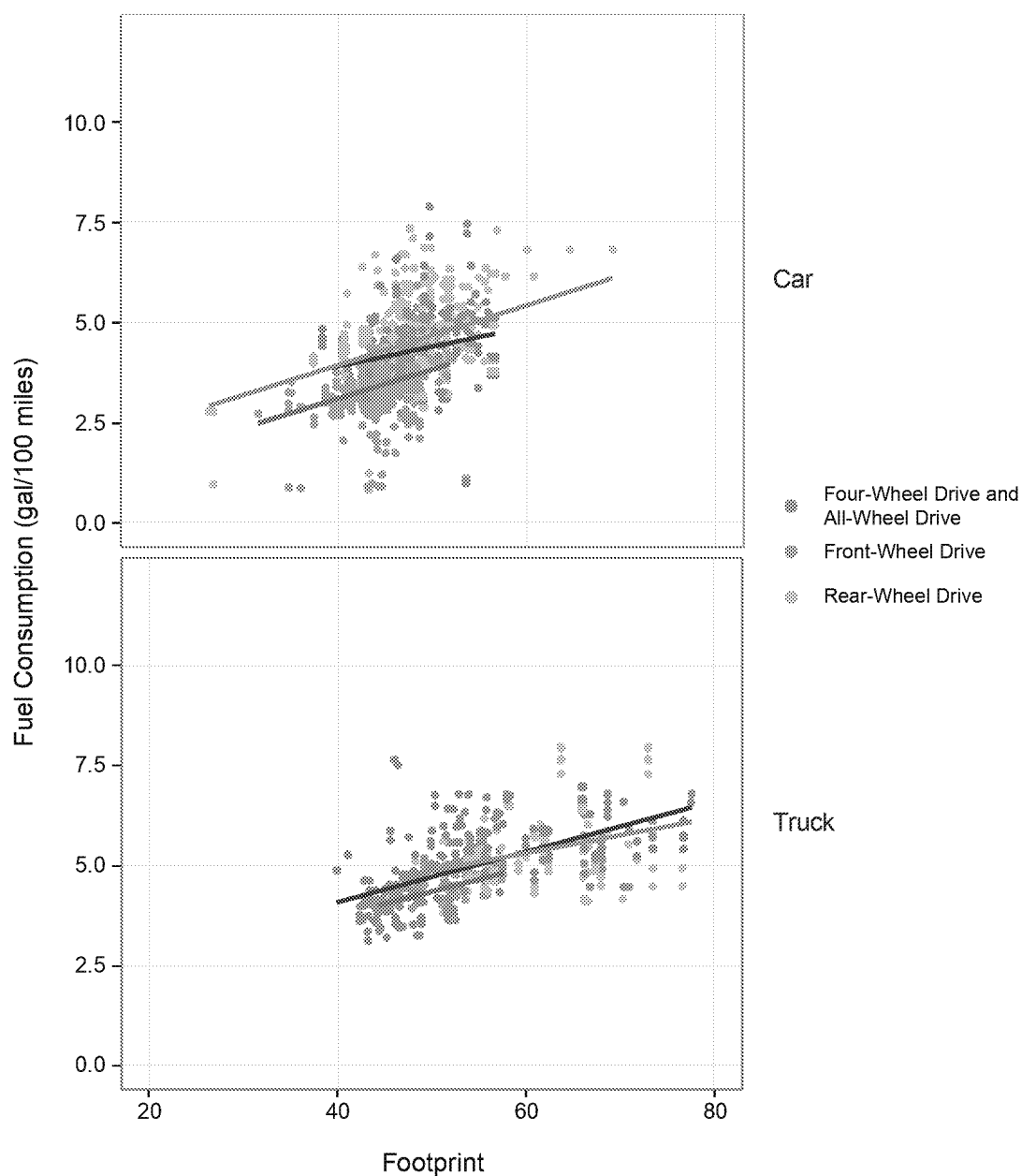
Tables 5.4.1, 5.4.2, and 5.4.3 summarize transmission production data by year for the combined car and truck fleet, cars only, and trucks only, respectively. Tables 5.5 summarizes the drive characteristics by year for the combined car and truck fleet, cars only, and trucks only, respectively.

Table 5.4.1

Transmission Technologies, Both Car and Truck

Model Year	Manual	Automatic with Lockup	Automatic without Lockup	CVT (Hybrid)	CVT (Non-Hybrid)	Other	4 Gears or Fewer	5 Gears	6 Gears	7 Gears	8 Gears	9+ Gears	CVT (Hybrid)	CVT (Non-Hybrid)	Average Number of Gears
1975	23.0%	0.2%	76.8%	-	-	-	99.0%	1.0%	-	-	-	-	-	-	-
1976	20.9%	-	79.1%	-	-	-	100.0%	-	-	-	-	-	-	-	-
1977	19.8%	-	80.2%	-	-	-	100.0%	-	-	-	-	-	-	-	-
1978	22.7%	5.5%	71.9%	-	-	-	92.7%	7.3%	-	-	-	-	-	-	-
1979	24.2%	7.3%	68.1%	-	-	0.4%	93.8%	6.2%	-	-	-	-	-	-	3.3
1980	34.6%	18.1%	46.8%	-	-	0.5%	87.9%	12.1%	-	-	-	-	-	-	3.5
1981	33.6%	33.0%	32.9%	-	-	0.5%	85.6%	14.4%	-	-	-	-	-	-	3.5
1982	32.4%	47.8%	19.4%	-	-	0.4%	84.4%	15.6%	-	-	-	-	-	-	3.6
1983	30.5%	52.1%	17.0%	-	-	0.4%	80.9%	19.1%	-	-	-	-	-	-	3.7
1984	28.4%	52.8%	18.8%	-	-	0.0%	81.3%	18.7%	-	-	-	-	-	-	3.7
1985	26.5%	54.5%	19.1%	-	-	-	80.7%	19.3%	-	-	-	-	-	-	3.8
1986	29.8%	53.5%	16.7%	-	-	-	76.8%	23.2%	-	-	-	-	-	-	3.8
1987	29.1%	55.4%	15.5%	-	-	0.0%	76.2%	23.8%	-	-	-	-	-	-	3.9
1988	27.6%	62.2%	10.2%	-	-	-	76.8%	23.2%	-	-	-	-	-	-	3.9
1989	24.6%	65.5%	9.9%	-	0.1%	0.0%	78.5%	21.4%	0.0%	-	-	-	-	0.1%	3.9
1990	22.2%	71.2%	6.5%	-	0.0%	0.0%	79.9%	20.0%	0.1%	-	-	-	-	0.0%	4.0
1991	23.9%	71.6%	4.5%	-	0.0%	-	77.3%	22.6%	0.0%	-	-	-	-	0.0%	4.0
1992	20.7%	74.8%	4.5%	-	0.0%	-	80.8%	19.2%	0.1%	-	-	-	-	0.0%	4.0
1993	19.8%	76.5%	3.7%	-	0.0%	-	80.9%	19.0%	0.1%	-	-	-	-	0.0%	4.0
1994	19.5%	77.6%	3.0%	-	-	-	80.8%	19.0%	0.2%	-	-	-	-	-	4.1
1995	17.9%	80.7%	1.4%	-	-	-	82.0%	17.7%	0.2%	-	-	-	-	-	4.1
1996	15.2%	83.5%	1.3%	-	0.0%	0.0%	84.7%	15.1%	0.2%	-	-	-	-	0.0%	4.1
1997	14.0%	85.5%	0.5%	-	0.0%	-	82.4%	17.3%	0.2%	-	-	-	-	0.0%	4.1
1998	12.8%	86.7%	0.5%	-	0.0%	-	82.1%	17.7%	0.2%	-	-	-	-	0.0%	4.1
1999	10.1%	89.4%	0.5%	-	0.0%	-	84.4%	15.3%	0.3%	-	-	-	-	0.0%	4.1
2000	9.7%	89.5%	0.7%	-	0.0%	-	83.7%	15.8%	0.5%	-	-	-	-	0.0%	4.1
2001	9.0%	90.3%	0.6%	0.1%	0.0%	-	80.7%	18.5%	0.7%	-	-	-	0.1%	0.0%	4.2
2002	8.2%	91.4%	0.3%	0.1%	0.1%	-	77.1%	21.6%	1.1%	-	-	-	0.1%	0.1%	4.2
2003	8.0%	90.8%	0.1%	0.3%	0.8%	-	69.2%	28.1%	1.7%	-	-	-	0.3%	0.8%	4.3
2004	6.8%	91.8%	0.3%	0.4%	0.7%	-	63.9%	31.8%	3.0%	0.2%	-	-	0.4%	0.7%	4.4
2005	6.2%	91.5%	0.1%	1.0%	1.3%	-	56.0%	37.3%	4.1%	0.2%	-	-	1.0%	1.3%	4.5
2006	6.5%	90.6%	0.0%	1.5%	1.4%	-	47.7%	39.2%	8.8%	1.4%	-	-	1.5%	1.4%	4.6
2007	5.6%	87.1%	0.0%	2.1%	5.1%	-	40.5%	36.1%	14.4%	1.5%	0.2%	-	2.1%	5.1%	4.8
2008	5.2%	86.8%	0.2%	2.4%	5.5%	-	38.8%	31.9%	19.4%	1.8%	0.2%	-	2.4%	5.5%	4.8
2009	4.8%	85.6%	0.2%	2.1%	7.3%	-	31.2%	32.2%	24.5%	2.5%	0.1%	-	2.1%	7.3%	5.0
2010	3.8%	84.1%	1.2%	3.8%	7.2%	-	24.6%	23.5%	38.1%	2.7%	0.2%	-	3.8%	7.2%	5.2
2011	3.2%	86.5%	0.3%	2.0%	8.0%	-	14.2%	18.7%	52.3%	3.1%	1.7%	-	2.0%	8.0%	5.5
2012	3.6%	83.4%	1.1%	2.7%	9.2%	-	8.1%	18.2%	56.3%	2.8%	2.6%	-	2.7%	9.2%	5.5
2013	3.5%	80.4%	1.4%	2.9%	11.8%	-	5.4%	12.8%	60.1%	2.8%	4.1%	-	2.9%	11.8%	5.6
2014	2.8%	76.7%	1.6%	2.3%	16.6%	-	2.2%	7.8%	58.4%	3.3%	8.4%	1.1%	2.3%	16.6%	5.9
2015	2.6%	72.3%	1.4%	2.2%	21.5%	-	1.5%	4.5%	54.2%	3.1%	9.5%	3.5%	2.2%	21.5%	5.9
2016 (prelim)	3.1%	72.0%	3.5%	2.1%	19.2%	-	1.9%	2.4%	55.0%	2.8%	11.8%	4.7%	2.1%	19.2%	6.0

Table 5.4.2

Transmission Technologies, Car Only

Model Year	Manual	Automatic with Lockup	Automatic without Lockup	CVT (Hybrid)	CVT (Non-Hybrid)	Other	4 Gears or Fewer	5 Gears	6 Gears	7 Gears	8 Gears	9+ Gears	CVT (Hybrid)	CVT (Non-Hybrid)	Average Number of Gears
1975	19.7%	0.3%	80.0%	-	-	-	98.7%	1.3%	-	-	-	-	-	-	-
1976	17.2%	-	82.8%	-	-	-	100.0%	-	-	-	-	-	-	-	-
1977	16.9%	-	83.1%	-	-	-	100.0%	-	-	-	-	-	-	-	-
1978	19.9%	7.1%	73.0%	-	-	-	90.7%	9.3%	-	-	-	-	-	-	-
1979	21.1%	8.8%	69.6%	-	-	0.5%	93.1%	6.9%	-	-	-	-	-	-	3.3
1980	30.9%	16.8%	51.6%	-	-	0.6%	87.6%	12.4%	-	-	-	-	-	-	3.5
1981	29.9%	33.3%	36.2%	-	-	0.6%	85.5%	14.5%	-	-	-	-	-	-	3.5
1982	29.2%	51.3%	19.1%	-	-	0.5%	84.6%	15.4%	-	-	-	-	-	-	3.6
1983	26.0%	56.7%	16.8%	-	-	0.5%	80.8%	19.2%	-	-	-	-	-	-	3.7
1984	24.1%	58.3%	17.5%	-	-	0.0%	82.1%	17.9%	-	-	-	-	-	-	3.7
1985	22.8%	58.9%	18.4%	-	-	-	81.4%	18.6%	-	-	-	-	-	-	3.7
1986	24.7%	58.1%	17.1%	-	-	-	79.7%	20.3%	-	-	-	-	-	-	3.8
1987	24.8%	59.7%	15.5%	-	-	-	78.4%	21.6%	-	-	-	-	-	-	3.8
1988	24.3%	66.2%	9.5%	-	-	-	80.2%	19.8%	-	-	-	-	-	-	3.8
1989	21.1%	69.3%	9.5%	-	0.1%	-	81.9%	17.9%	0.0%	-	-	-	-	0.1%	3.9
1990	19.8%	72.8%	7.4%	-	0.0%	-	82.4%	17.5%	0.1%	-	-	-	-	0.0%	3.9
1991	20.6%	73.7%	5.7%	-	0.0%	-	81.0%	18.9%	0.1%	-	-	-	-	0.0%	3.9
1992	17.6%	76.4%	6.0%	-	0.0%	-	83.6%	16.3%	0.1%	-	-	-	-	0.0%	3.9
1993	17.5%	77.6%	4.9%	-	0.0%	-	83.2%	16.6%	0.2%	-	-	-	-	0.0%	4.0
1994	16.9%	78.9%	4.1%	-	-	-	83.4%	16.3%	0.3%	-	-	-	-	-	4.0
1995	16.3%	81.9%	1.8%	-	-	-	83.4%	16.2%	0.4%	-	-	-	-	-	4.1
1996	14.9%	83.6%	1.5%	-	0.0%	-	84.9%	14.7%	0.3%	-	-	-	-	0.0%	4.1
1997	13.9%	85.2%	0.8%	-	0.1%	-	84.1%	15.5%	0.3%	-	-	-	-	0.1%	4.1
1998	12.2%	87.4%	0.3%	-	0.1%	-	82.8%	16.8%	0.3%	-	-	-	-	0.1%	4.1
1999	10.8%	88.6%	0.6%	-	0.0%	-	83.4%	16.1%	0.5%	-	-	-	-	0.0%	4.1
2000	10.8%	88.1%	1.0%	-	0.0%	-	81.3%	17.9%	0.8%	-	-	-	-	0.0%	4.1
2001	11.0%	88.0%	0.8%	0.2%	0.0%	-	78.5%	20.2%	1.2%	-	-	-	0.2%	0.0%	4.2
2002	10.9%	88.4%	0.2%	0.3%	0.1%	-	77.4%	20.3%	1.9%	-	-	-	0.3%	0.1%	4.2
2003	10.9%	87.7%	-	0.5%	1.0%	-	67.5%	27.9%	3.1%	-	-	-	0.5%	1.0%	4.3
2004	9.8%	88.2%	0.2%	0.8%	0.9%	-	64.5%	28.4%	5.0%	0.4%	-	-	0.8%	0.9%	4.4
2005	8.8%	88.4%	0.1%	1.7%	1.1%	-	57.3%	33.7%	5.8%	0.4%	-	-	1.7%	1.1%	4.5
2006	8.8%	88.4%	0.1%	1.5%	1.2%	-	47.5%	35.4%	12.5%	1.9%	-	-	1.5%	1.2%	4.7
2007	7.8%	82.5%	0.0%	3.0%	6.7%	-	36.8%	34.7%	16.5%	1.9%	0.4%	-	3.0%	6.7%	4.8
2008	7.2%	81.7%	0.3%	3.2%	7.7%	-	39.3%	28.2%	19.0%	2.2%	0.4%	-	3.2%	7.7%	4.8
2009	6.2%	82.4%	0.3%	2.8%	8.3%	-	35.1%	31.4%	19.3%	2.9%	0.2%	-	2.8%	8.3%	4.9
2010	5.0%	79.4%	1.6%	5.5%	8.4%	-	29.5%	20.2%	33.0%	3.1%	0.3%	-	5.5%	8.4%	5.1
2011	4.6%	83.0%	0.5%	3.1%	8.8%	-	15.9%	12.9%	53.7%	3.9%	1.6%	-	3.1%	8.8%	5.6
2012	4.9%	78.4%	1.8%	4.0%	11.0%	-	6.9%	14.8%	57.2%	3.2%	2.9%	-	4.0%	11.0%	5.5
2013	4.8%	75.0%	2.2%	4.3%	13.7%	-	5.8%	8.6%	60.0%	3.3%	4.2%	-	4.3%	13.7%	5.5
2014	4.0%	68.4%	2.7%	3.7%	21.3%	-	2.6%	4.4%	58.0%	4.3%	5.2%	0.6%	3.7%	21.3%	5.8
2015	3.9%	63.9%	2.3%	3.6%	26.3%	-	1.8%	1.1%	52.4%	3.8%	7.3%	3.8%	3.6%	26.3%	5.9
2016 (prelim)	4.3%	64.3%	5.1%	3.0%	23.3%	-	2.8%	0.8%	52.7%	3.6%	10.0%	3.9%	3.0%	23.3%	5.9

Table 5.4.3

Transmission Technologies, Truck Only

Model Year	Manual	Automatic with Lockup	Automatic without Lockup	CVT (Hybrid)	CVT (Non-Hybrid)	Other	4 Gears or Fewer	5 Gears	6 Gears	7 Gears	8 Gears	9+ Gears	CVT (Hybrid)	CVT (Non-Hybrid)	Average Number of Gears
1975	36.9%	-	63.1%	-	-	-	100.0%	-	-	-	-	-	-	-	-
1976	34.7%	-	65.3%	-	-	-	100.0%	-	-	-	-	-	-	-	-
1977	31.6%	-	68.4%	-	-	-	100.0%	-	-	-	-	-	-	-	-
1978	32.1%	-	67.9%	-	-	-	99.3%	0.7%	-	-	-	-	-	-	-
1979	35.1%	2.1%	62.8%	-	-	-	96.0%	4.0%	-	-	-	-	-	-	3.3
1980	53.0%	24.5%	22.4%	-	-	-	89.2%	10.8%	-	-	-	-	-	-	3.5
1981	51.6%	31.1%	17.3%	-	-	-	86.1%	13.9%	-	-	-	-	-	-	3.6
1982	45.9%	33.4%	20.7%	-	-	-	83.8%	16.2%	-	-	-	-	-	-	3.7
1983	46.3%	36.0%	17.4%	-	-	0.3%	81.6%	18.4%	-	-	-	-	-	-	3.9
1984	42.5%	34.6%	22.9%	-	-	0.0%	78.6%	21.4%	-	-	-	-	-	-	3.9
1985	37.6%	41.1%	21.2%	-	-	-	78.6%	21.4%	-	-	-	-	-	-	3.8
1986	43.0%	41.5%	15.5%	-	-	-	69.1%	30.9%	-	-	-	-	-	-	4.0
1987	40.5%	43.8%	15.7%	-	-	0.1%	70.1%	29.9%	-	-	-	-	-	-	4.0
1988	35.8%	52.5%	11.7%	-	-	-	68.4%	31.6%	-	-	-	-	-	-	4.1
1989	32.8%	56.4%	10.8%	-	-	0.0%	70.3%	29.7%	-	-	-	-	-	-	4.1
1990	28.1%	67.5%	4.4%	-	-	0.0%	74.1%	25.9%	-	-	-	-	-	-	4.1
1991	31.5%	66.8%	1.7%	-	-	-	69.0%	31.0%	-	-	-	-	-	-	4.2
1992	27.5%	71.3%	1.2%	-	-	-	74.6%	25.4%	-	-	-	-	-	-	4.2
1993	24.7%	74.2%	1.1%	-	-	-	76.0%	24.0%	-	-	-	-	-	-	4.2
1994	23.7%	75.3%	1.0%	-	-	-	76.7%	23.3%	-	-	-	-	-	-	4.2
1995	20.7%	78.5%	0.9%	-	-	-	79.6%	20.4%	-	-	-	-	-	-	4.2
1996	15.6%	83.4%	1.0%	-	-	0.0%	84.4%	15.6%	-	-	-	-	-	-	4.1
1997	14.1%	85.8%	0.1%	-	-	-	79.9%	20.1%	-	-	-	-	-	-	4.2
1998	13.6%	85.8%	0.6%	-	-	-	81.1%	18.9%	-	-	-	-	-	-	4.2
1999	9.2%	90.4%	0.4%	-	-	-	85.8%	14.2%	-	-	-	-	-	-	4.1
2000	8.2%	91.5%	0.3%	-	-	-	87.3%	12.7%	-	-	-	-	-	-	4.1
2001	6.3%	93.4%	0.3%	-	-	-	84.0%	16.0%	-	-	-	-	-	-	4.2
2002	4.7%	94.9%	0.3%	-	0.0%	-	76.7%	23.3%	-	-	-	-	-	0.0%	4.2
2003	4.6%	94.4%	0.3%	-	0.6%	-	71.1%	28.2%	-	-	-	-	-	0.6%	4.3
2004	3.5%	95.6%	0.3%	-	0.6%	-	63.2%	35.5%	0.8%	-	-	-	-	0.6%	4.4
2005	2.9%	95.3%	-	0.1%	1.7%	-	54.3%	41.9%	2.1%	-	-	-	0.1%	1.7%	4.5
2006	3.3%	93.7%	-	1.5%	1.6%	-	48.0%	44.3%	3.8%	0.8%	-	-	1.5%	1.6%	4.6
2007	2.6%	93.8%	-	0.7%	2.9%	-	45.8%	38.0%	11.5%	1.0%	-	-	0.7%	2.9%	4.7
2008	2.2%	94.1%	-	1.3%	2.3%	-	37.9%	37.4%	19.9%	1.2%	-	-	1.3%	2.3%	4.8
2009	2.0%	92.0%	-	0.9%	5.1%	-	23.4%	33.7%	35.2%	1.6%	-	-	0.9%	5.1%	5.2
2010	1.8%	91.9%	0.4%	0.8%	5.1%	-	16.4%	29.1%	46.7%	1.9%	-	-	0.8%	5.1%	5.4
2011	1.3%	91.4%	0.0%	0.4%	6.9%	-	11.9%	26.5%	50.5%	1.9%	1.9%	-	0.4%	6.9%	5.5
2012	1.4%	92.4%	-	0.3%	5.9%	-	10.4%	24.4%	54.6%	2.2%	2.2%	-	0.3%	5.9%	5.6
2013	1.1%	90.2%	-	0.4%	8.4%	-	4.7%	20.2%	60.3%	2.0%	4.0%	-	0.4%	8.4%	5.7
2014	0.9%	88.9%	-	0.3%	9.8%	-	1.5%	12.7%	59.1%	1.8%	13.0%	1.8%	0.3%	9.8%	6.1
2015	0.9%	83.6%	0.2%	0.3%	15.0%	-	1.1%	9.0%	56.7%	2.2%	12.5%	3.1%	0.3%	15.0%	6.0
2016 (prelim)	1.2%	84.6%	0.9%	0.8%	12.5%	-	0.6%	5.0%	58.9%	1.5%	14.8%	6.0%	0.8%	12.5%	6.2

Table 5.5

Production Share by Drive Technology

Model Year	Car			Truck			Both		
	Front Wheel Drive	Rear Wheel Drive	Four Wheel Drive	Front Wheel Drive	Rear Wheel Drive	Four Wheel Drive	Front Wheel Drive	Rear Wheel Drive	Four Wheel Drive
1975	6.5%	93.5%	-	-	82.8%	17.2%	5.3%	91.4%	3.3%
1976	5.8%	94.2%	-	-	77.0%	23.0%	4.6%	90.6%	4.8%
1977	6.8%	93.2%	-	-	76.2%	23.8%	5.5%	89.8%	4.7%
1978	9.6%	90.4%	-	-	70.9%	29.1%	7.4%	86.0%	6.6%
1979	11.9%	87.8%	0.3%	-	81.9%	18.1%	9.2%	86.5%	4.3%
1980	29.7%	69.4%	0.9%	1.4%	73.6%	25.0%	25.0%	70.1%	4.9%
1981	37.0%	62.2%	0.7%	1.9%	78.0%	20.1%	31.0%	65.0%	4.0%
1982	45.6%	53.6%	0.8%	1.7%	78.1%	20.2%	37.0%	58.4%	4.6%
1983	47.1%	49.9%	3.1%	1.4%	72.5%	26.1%	37.0%	54.8%	8.1%
1984	53.5%	45.5%	1.0%	5.0%	63.5%	31.5%	42.1%	49.8%	8.2%
1985	61.1%	36.8%	2.1%	7.3%	61.4%	31.3%	47.8%	42.9%	9.3%
1986	70.7%	28.2%	1.0%	5.9%	63.4%	30.7%	52.6%	38.0%	9.3%
1987	76.4%	22.6%	1.1%	7.6%	60.2%	32.2%	57.7%	32.8%	9.6%
1988	80.9%	18.3%	0.8%	9.2%	56.7%	34.1%	60.0%	29.5%	10.5%
1989	81.6%	17.4%	1.0%	10.1%	57.1%	32.8%	60.2%	29.3%	10.5%
1990	84.0%	15.0%	1.0%	15.8%	52.4%	31.8%	63.8%	26.1%	10.1%
1991	81.1%	17.5%	1.3%	10.3%	52.3%	37.3%	59.6%	28.1%	12.3%
1992	78.4%	20.5%	1.1%	14.5%	52.1%	33.4%	58.4%	30.4%	11.2%
1993	80.6%	18.3%	1.1%	16.8%	50.6%	32.7%	59.9%	28.8%	11.3%
1994	81.3%	18.3%	0.4%	13.8%	47.0%	39.2%	55.6%	29.2%	15.2%
1995	80.1%	18.8%	1.1%	18.4%	39.3%	42.3%	57.6%	26.3%	16.2%
1996	83.7%	14.8%	1.4%	20.9%	39.8%	39.2%	60.0%	24.3%	15.7%
1997	83.8%	14.5%	1.7%	14.2%	40.6%	45.2%	56.1%	24.9%	19.0%
1998	82.9%	15.0%	2.1%	19.3%	35.5%	45.1%	56.4%	23.5%	20.1%
1999	83.2%	14.7%	2.1%	17.5%	34.4%	48.1%	55.8%	22.9%	21.3%
2000	80.4%	17.7%	2.0%	20.0%	33.8%	46.3%	55.5%	24.3%	20.2%
2001	80.3%	16.7%	3.0%	16.3%	34.8%	48.8%	53.8%	24.2%	22.0%
2002	82.9%	13.5%	3.6%	15.4%	33.1%	51.6%	52.7%	22.3%	25.0%
2003	80.9%	15.9%	3.2%	15.4%	34.1%	50.4%	50.7%	24.3%	25.0%
2004	80.2%	14.5%	5.3%	12.5%	31.0%	56.5%	47.7%	22.4%	29.8%
2005	79.2%	14.2%	6.6%	20.1%	27.7%	52.2%	53.0%	20.2%	26.8%
2006	75.9%	18.0%	6.0%	18.9%	28.0%	53.1%	51.9%	22.3%	25.8%
2007	81.0%	13.4%	5.6%	16.1%	28.4%	55.5%	54.3%	19.6%	26.1%
2008	78.8%	14.1%	7.1%	18.4%	24.8%	56.8%	54.2%	18.5%	27.3%
2009	83.5%	10.2%	6.3%	21.0%	20.5%	58.5%	62.9%	13.6%	23.5%
2010	82.5%	11.2%	6.3%	20.9%	18.0%	61.0%	59.6%	13.7%	26.7%
2011	80.1%	11.3%	8.6%	17.7%	17.3%	65.0%	53.8%	13.8%	32.4%
2012	83.8%	8.8%	7.5%	20.9%	14.8%	64.3%	61.4%	10.9%	27.7%
2013	83.0%	9.3%	7.7%	18.1%	14.5%	67.5%	59.7%	11.1%	29.1%
2014	81.3%	10.6%	8.2%	17.5%	14.2%	68.3%	55.3%	12.1%	32.6%
2015	80.4%	9.7%	9.9%	16.0%	12.6%	71.4%	52.9%	10.9%	36.1%
2016 (prelim)	79.2%	9.9%	10.9%	16.0%	12.4%	71.6%	55.2%	10.8%	34.0%

Technology in new vehicles is continually changing and evolving. Innovative new technologies are regularly being introduced, replacing older and less effective technologies. This continuous cycle of improvement and re-invention has been the driving force behind nearly all of the trends examined in this report. Section 5 detailed many specific technological changes that have taken place since 1975. This section provides a detailed look at the rate at which the automotive industry as a whole has adopted new technology, the rate at which individual manufacturers have adopted technology, and the differences between the overall industry and manufacturer adoption rates. In recent years, several other studies have examined technology penetration trends in the automotive industry, notably researchers at Argonne National Laboratory (Plotkin, et al. 2013), MIT's Sloan Automotive Laboratory (Zoepf and Heywood 2013), EPA, and The University of Michigan (DeCicco 2010).

It is important to note that this section focuses on technologies that have achieved widespread use by multiple manufacturers and, in some cases, by all or nearly all manufacturers. This section does not look at narrowly-adopted technologies which never achieved widespread use. One consequence of a competitive and technology-driven enterprise like the automobile industry is that there will certainly be many technologies which do not achieve widespread use. A technology may not achieve widespread use for one or more of many reasons: cost, effectiveness, tradeoffs with other vehicle attributes, consumer acceptance, or, in some cases, the technology may be successful for a time but later displaced by a newer and better technology. The Trends database does not provide data on why technologies do not achieve widespread adoption, but it does provide data on how quickly successful technologies can penetrate the marketplace, and the latter is the subject of this section.

One inherent limitation in using the Trends database to track the introduction of new technologies is that there is often a lag between the introduction of a new technology and the modifications to the formal EPA vehicle compliance information system that are necessary to ensure proper tracking of the new technology. Accordingly, for many of the technologies discussed in this section, the Trends database did not begin tracking production share data until after the technologies had achieved some limited market share. For example, as shown in Tables 5.3.2 and 5.3.3, Trends did not begin to track multi-valve engine data until MY 1986 for cars and MY 1994 for trucks, and in both cases multi-valve engines had captured about 5% market share by that time. Likewise, turbochargers were not tracked in Trends until MY 1996 for cars and MY 2003 for trucks, and while turbochargers had less than a 1% market share in both cases at that time, it is likely that turbochargers had exceeded 1% market share in the late 1980s. Cylinder deactivation was utilized by at least one major manufacturer in the 1980s, well before being tracked by Trends.

Accordingly, this section best addresses the question, "How quickly have successful technologies moved from limited use to widespread use," for both industry-wide and for individual manufacturers, and does not address other important issues such as how long it takes for technologies to be developed or to achieve limited market share, or why many technologies fail to ever achieve widespread use.

A. Industry-Wide Technology Adoption Since 1975

Automotive technology has continually evolved since 1975, resulting in vehicles that have better fuel economy, more power, and more content. One of the most notable examples of this continual improvement is the evolution of fuel delivery in gasoline engines. Carburetors, the dominant fuel delivery system in the late 1970s and early 1980s, were replaced by port fuel injection systems, which in turn are being replaced by direct injection systems. This trend, and the substantial impact on engine fuel economy and performance, is explored in Figures 5.1 and 5.5.

Figure 6.1 has been published in this report for many years, and has been widely cited in the literature. This figure shows industry-wide adoption rates for seven technologies in passenger cars. Six of these technologies have achieved wide adoption across the entire industry, and one newer technology appears to be quickly headed towards widespread adoption. To provide a common scale, the adoption rates are plotted in terms of the number of years after the technology achieved first significant use in the industry. First significant use generally represents a production threshold of 1%, though in some cases, where full data is not available, first significant use represents a slightly higher production share. The seven technologies included in Figure 6.1 are fuel injection (including throttle body, port, and direct injection), front wheel drive, multi-valve engines (i.e., engines with more than two valves per cylinder), engines with variable valve timing, lockup transmissions, advanced transmissions (transmissions with 6 or more speeds, and CVTs), and gasoline direct injection engines (GDI).

The technology adoption pattern shown in Figure 6.1 is roughly similar for each of the seven technologies, even though they vary widely in application, complexity, and when they were initially introduced. It has taken, on average, approximately 15-20 years for new technologies to reach maximum penetration across the industry. GDI is a newer technology that has likely not reached maximum penetration across the industry, but appears to be following the adoption trend of other more mature technologies. While some of these technologies may eventually be adopted in 100% of new vehicles, there may be reasons that other technologies, like front-wheel drive, will likely never be adopted in all vehicles. Adoption rates for these technologies in trucks are similar, with the exception of front wheel drive.

B. TECHNOLOGY ADOPTION BY MANUFACTURERS

The rate at which the overall industry adopts technology, as shown in Figure 6.1, is actually determined by how quickly, and at what point in time, individual manufacturers adopt the technology. While it is important to understand the industry-wide adoption rates over time, the trends in Figure 6.1 mask the fact that not all manufacturers introduced these technologies at the same time, or at the same rate. The "sequencing" of manufacturers introducing new technologies is an important aspect of understanding the overall industry trend of technology adoption.

Figure 6.2 begins to disaggregate the industry-wide trends shown in Figure 6.1 to examine how individual manufacturers have adopted new technologies. The first four technologies shown in Figure 6.2, which are also shown in Figure 6.1, have reached (or are near) full market penetration for all manufacturers. Also included in Figure 6.2 are three additional technologies that are quickly increasing penetration in new vehicle production, and are projected to be installed on at least 15% of all MY 2016 vehicles. These technologies are advanced transmissions (defined here as transmissions with 6 or more speeds and CVTs), gasoline direct injection (GDI) systems, and turbocharged engines. Figure 6.2 shows the percent penetration of each technology over time for the industry as a whole, and individually

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for the top seven manufacturers by sales. Figure 6.2 focuses on the length of time each manufacturer required to move from initial introduction to 80% penetration for each technology. After 80% penetration, the technology is assumed to be largely incorporated into the manufacturer's fleet and changes between 80% and 100% are not highlighted.

The technologies shown in Figure 6.2 vary widely in terms of complexity, application, and when they were introduced into the market. For each technology, there are clearly variations between manufacturers, both in terms of when they began to adopt a technology, and the rate with which they adopted the technology. The degree of variation between the manufacturers also varies by technology.

The data for variable valve timing (VVT), for example, shows that several manufactures were able to adopt the technology much faster than the overall industry rate might suggest. As shown in Figure 6.1, it took a little over 20 years for VVT to reach 80% penetration across the industry as a whole. However, Figure 6.2 shows that several individual manufacturers were able to implement at least 80% VVT in significantly less time than the overall industry. Therefore, it was not the rate of technology adoption alone, but rather the staggered implementation time frames among manufacturers that resulted in the longer industry-wide average.

Fuel injection systems show the least amount of variation in initial adoption timing between manufacturers, which resulted in a faster adoption by the industry overall (see Figure 6.1) than technologies like VVT. One important driver for adoption of fuel injection was increasingly stringent emissions standards. Advanced transmissions, and turbocharged engines, have been available in small numbers for some time, but have very rapidly increased market penetration in recent years. Turbocharged engines and GDI systems have only recently begun to reach significant parts of the market, and while both technologies are showing variation in adoption between manufacturers, it is too early to tell whether, and how quickly, they will ultimately be adopted industry-wide.

A different way to look at technology adoption patterns is to look at the maximum rate of change that manufacturers have been able to achieve for each technology. Figure 6.3 uses this approach to look at technology adoption for the same manufacturers and technologies examined in Figure 6.2. For each technology and manufacturer, Figure 6.3 shows the maximum change in technology penetration that each manufacturer achieved over any 3-year and 5-year period.

Figure 6.2

Manufacturer Specific Technology Adoption over Time for Key Technologies*
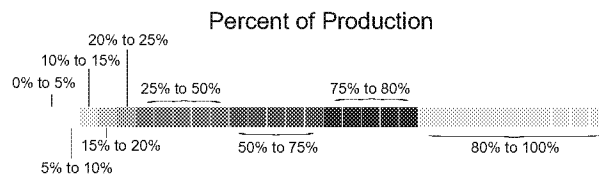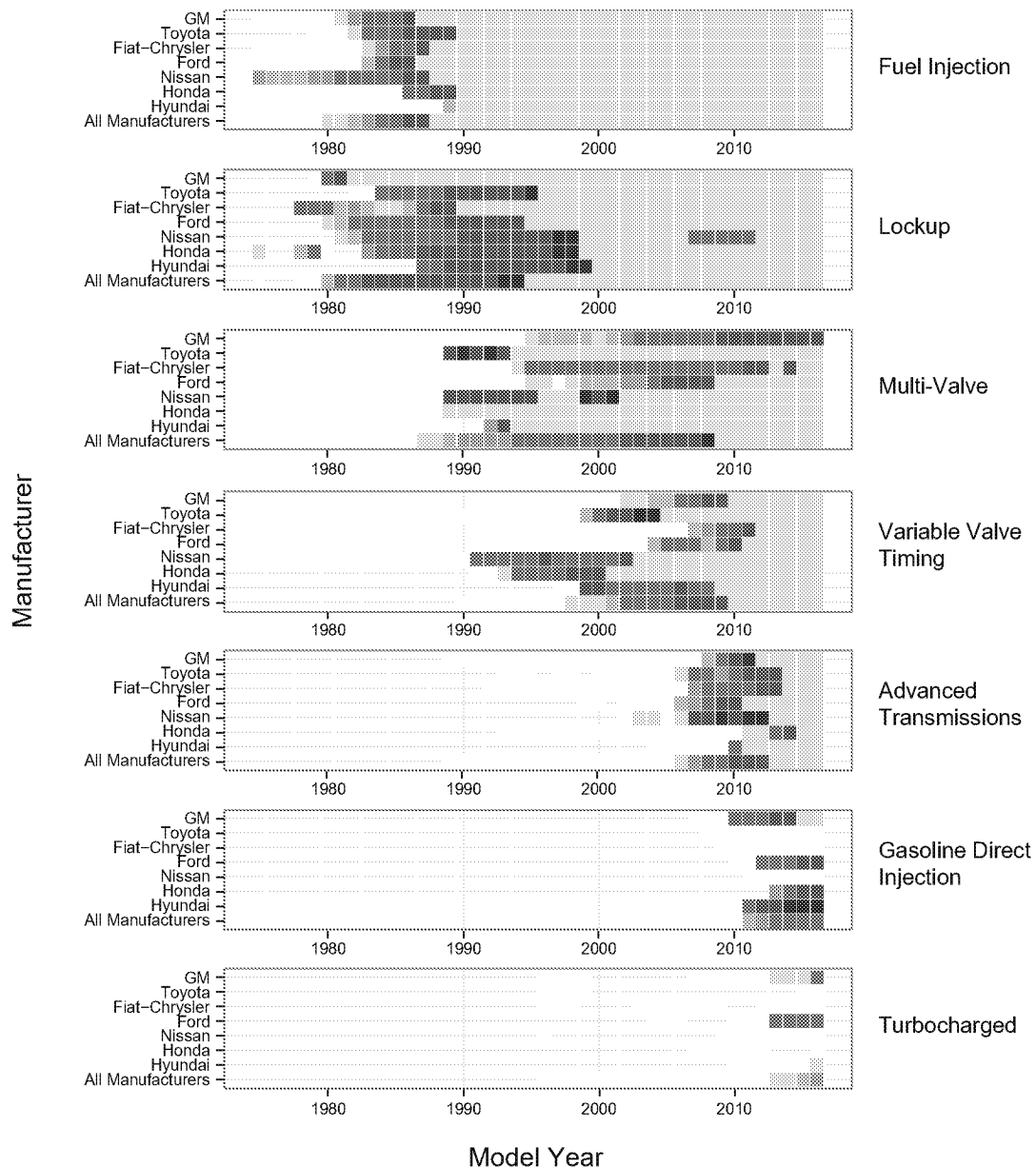
Fuel Injection

Lockup

Multi-Valve

Variable Valve Timing

Advanced Transmissions

Gasoline Direct Injection

Turbocharged

Model Year

Percent of Production

* This figure is based on available data. Some technologies may have been introduced into the market before this report began tracking them. Generally these omissions are limited, with the exception of multi-valve engine data for Honda. Honda had already achieved 70% penetration of multi-valve engines when this report began tracking multi-valve engines in 1986, so this figure does not illustrate Honda's increase prior to 1986.

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There are many examples of manufacturers that were able to apply new technology to a large percentage of their new vehicles in only 3 to 5 years. For example, each of the manufacturers was able to increase the percentage of their new vehicles with fuel injection systems by over 50% in 5 years, and three manufacturers were able to increase the percentage of their new vehicles with VVT by more than 85% in that time. For VVT, all of the manufacturers achieved close to or above a 70% penetration change in a 5-year period, but the industry as a whole only achieved a 40% change over any 5 years. This data reinforces the conclusion that the staggered timing of VVT adoption by individual manufacturers resulted in an overall industry adoption period that is longer than actually required by many (if not most) individual manufacturers.

One important note for Figure 6.3 is that, in some cases, individual manufacturers were already at high rates of adoption of some technologies before Trends started collecting data for that technology (for example, Honda was using multi-valve engines throughout its fleet when EPA starting monitoring multi-valve data in the mid-1980s). Data for "rates of increase" in such cases are artificially low.

Figure 6.4 takes a more detailed look at the introduction of VVT by individual manufacturers by combining aspects of both Figure 6.2 and Figure 6.3. For each manufacturer, Figure 6.4 shows the actual percent penetration of VVT over time (solid red line) versus the average for all manufacturers (dotted grey line), and compared to the maximum penetration by any manufacturer (solid grey line) over time. Figure 6.4 also shows when the largest increase in VVT penetration over any 1, 3, and 5 year period occurred as green, orange, and yellow boxes.

VVT was first tracked in this report for cars in MY 1990 and for trucks in MY 2000. Between MY 1990 and MY 2000, there may be a small number of trucks with VVT that are not accounted for in the data. However, the first trucks with VVT produced in larger volumes (greater than 50,000 vehicles) were produced in MY 1999 and MY 2000, so the discrepancy is not enough to noticeably alter the trends in the previous figures.

Figure 6.3

Maximum Three- and Five-Year Adoption for Key Technologies
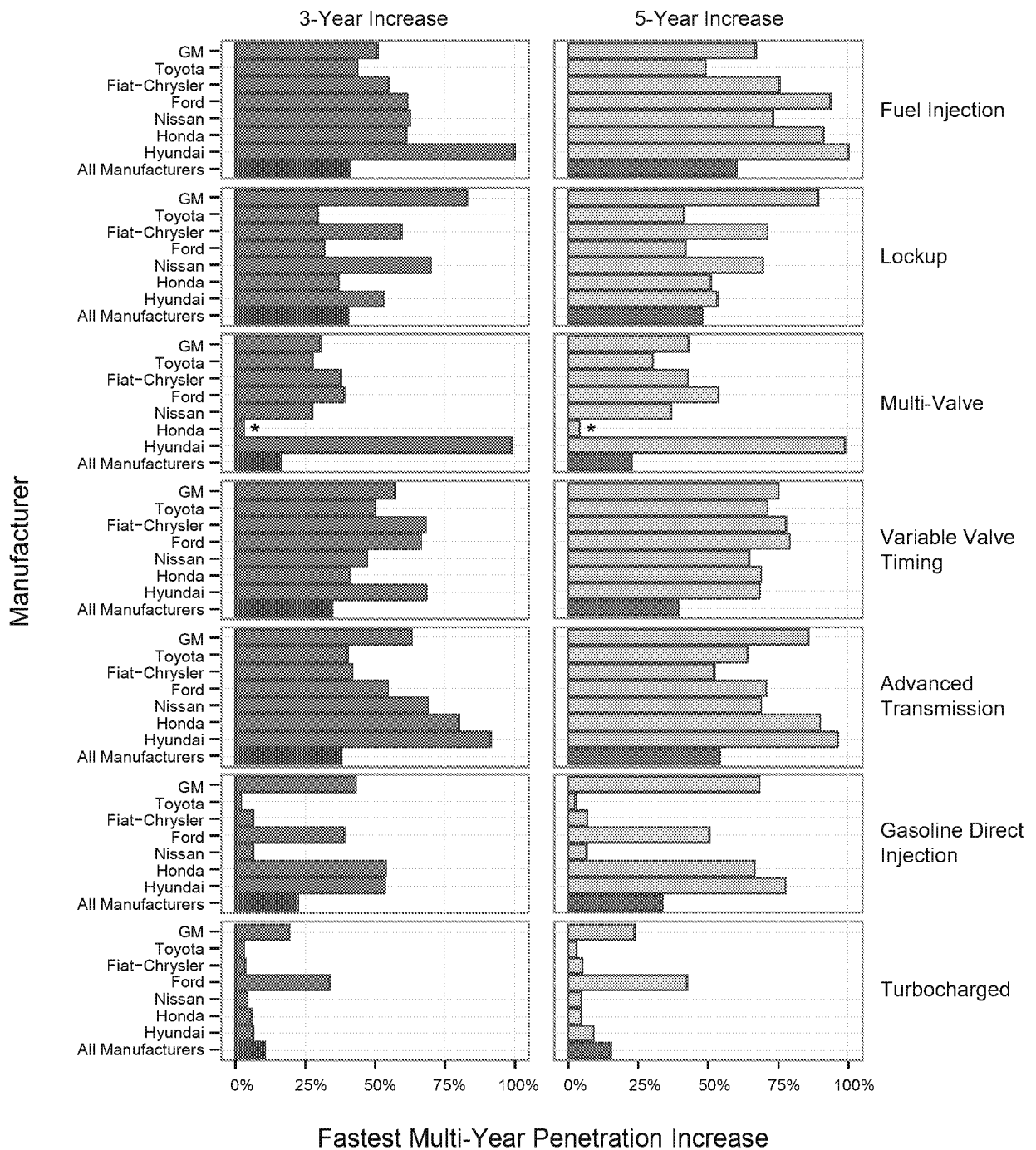
Fastest Multi-Year Penetration Increase

* This figure is based on available data. Some technologies may have been introduced into the market before this report began tracking them. Generally these omissions are limited, with the exception of multi-valve engine data for Honda. Honda had already achieved 70% penetration of multi-valve engines when this report began tracking multi-valve engines in 1986, so this figure does not illustrate Honda's increase prior to 1986.

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Figure 6.4

VVT Adoption Details by Manufacturer

Model Year
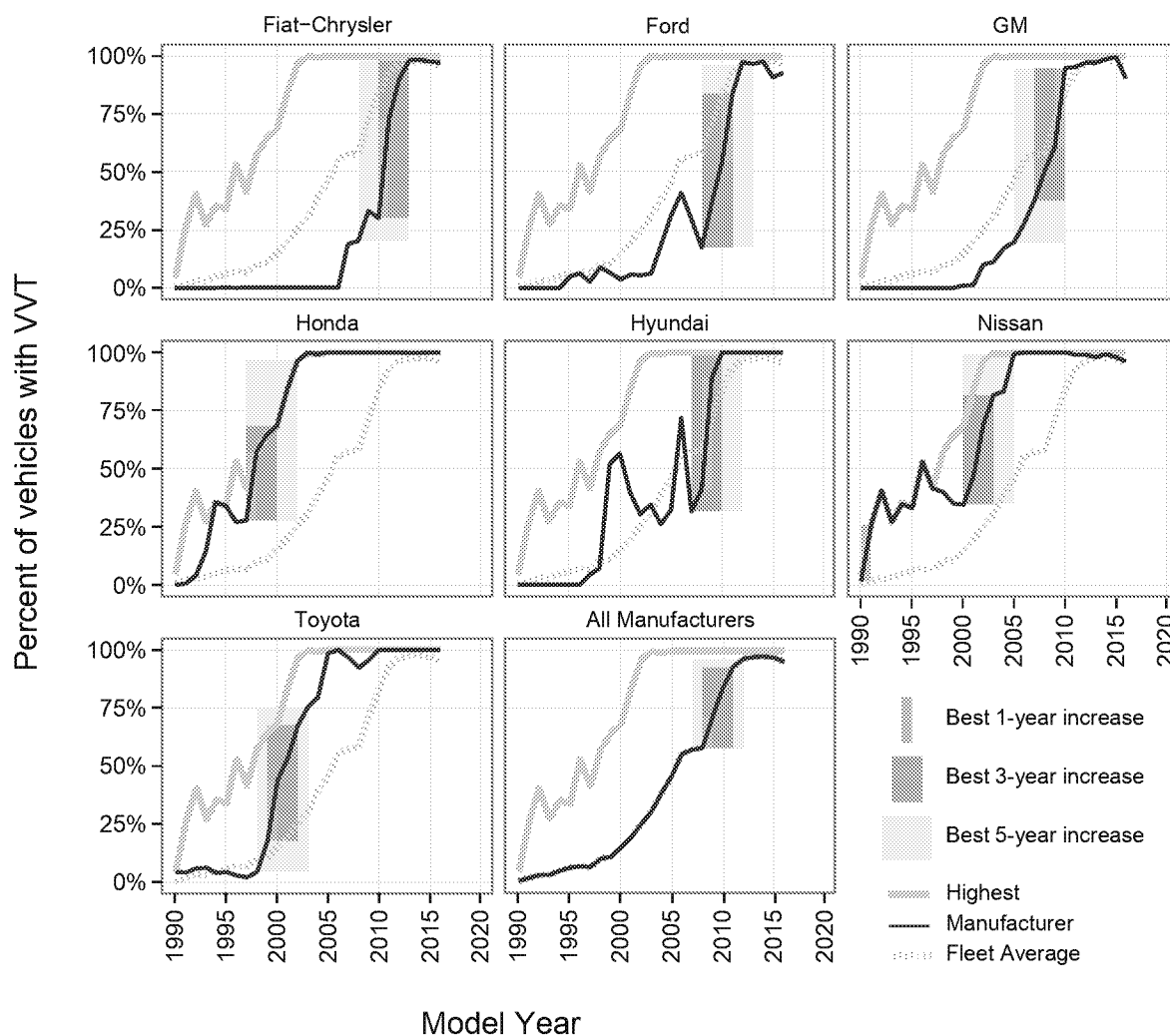
As shown in Figure 6.2, each manufacturer clearly followed a unique trajectory to adopt VVT. It took over 20 years for nearly all new vehicles to adopt VVT; however it is also very clear that individual manufacturers were able to adopt VVT across their own vehicle offerings much faster. All of the manufacturers shown in Figure 6.4 were able to adopt VVT across the vast majority of their new vehicle offerings in under 15 years, and many accomplished that feat in under 10 years. As indicated by the yellow rectangles in Figure 6.4, several manufacturers increased their penetration rates of VVT by 75% or more over a 5-year period. It is also important to note that every manufacturer shown was able to adopt VVT into new vehicles at a rate faster than the overall industry-wide data would imply. As noted earlier, the industry average represents both the rate that manufacturers adopted VVT and the effect of manufacturers adopting the technology at different times. Accordingly, the industry average shown in Figure 6.1 and Figure 6.4 does not represent the average pace at which individual manufacturers adopted VVT, which is considerably faster.

Figures 6.2 through 6.4 examine manufacturer specific technology adoption in different ways, but all three figures clearly support the conclusion that some manufacturers have been able to adopt technology much faster than industry-wide data suggest, and that there is significant

C. TECHNOLOGY ADOPTION IN THE LAST FIVE YEARS

Over the last five years, engines and transmissions have continued to evolve and adopt new technologies. Figure 6.5 shows the penetration of several key technologies in MY 2011 and the projected penetration for each technology in MY 2016 vehicles. Over that five-year span, GDI is projected to increase market share by about 33%, CVTs by more than 10%, and transmissions with 7 or more speeds by more than 15% across the entire industry. These are large changes taking place across the industry over a relatively short time. As discussed in the previous section, individual manufacturers are making technology changes at an even faster rate.

Figure 6.5
Five Year Change in Light Duty Vehicle Technology Penetration Share
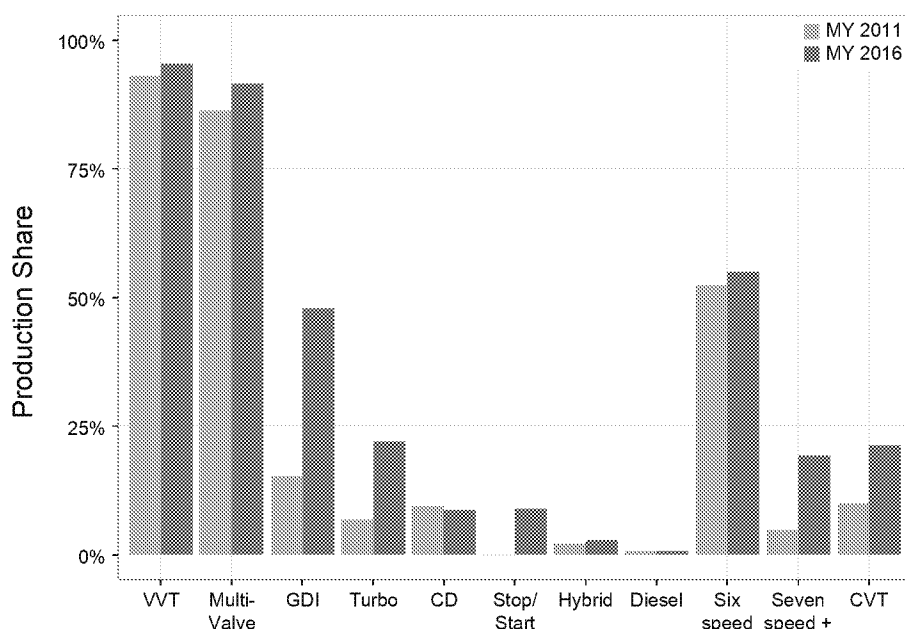
There are many factors outside the scope of this report that influence the rate and timing of when technology is adopted by individual manufactures (e.g., price, manufacturing constraints, regulatory drivers, etc.) While no attempt is made here to identify the underlying causes, it is important to recognize that variation between manufacturers for given technologies can be masked when only evaluating industry-wide trends. As the data in this section suggest, adoption by individual manufacturers is generally more rapid than has previously been reported for the overall industry, and it is clear that the penetration of important technologies has grown significantly over the last 5 years.

Alternative fuel vehicles (AFVs) are included in analyses throughout this report, except when noted otherwise. While overall market penetration of AFVs is still low, AFVs production share is expected to exceed 1% in MY 2016. As shown in Section 4, manufacturers with higher AFV production are already showing fuel economy increases and reductions in CO_2 emission rates due to AFVs. Section 5 shows how AFV production has increased over time. This section addresses some of the technical metrics used to quantify AFV operation and to integrate AFV data with gasoline and diesel vehicle data.

Vehicles included as AFVs throughout this report are those vehicles that are produced by original equipment manufacturers (OEMs) which are dedicated to, or are designed and expected to frequently operate on, alternative fuels such as electricity, natural gas, and hydrogen. Non-OEM vehicles that are converted to alternative fuels by independent, aftermarket companies are *not* included in this report. Ethanol flexible fuel vehicles are widely available, but the great majority of these vehicles are operated primarily on gasoline[6] and therefore are not included as AFVs in this report. OEM vehicles that operate predominantly on other alternative fuels, including methanol, propane, etc., will be included in future reports if they become generally available to the public.

The focus of this section is on MY 2016 vehicles. For consistency and clarity for the reader, the data for specific vehicles discussed in this section reflect values from the EPA/DOT Fuel Economy and Environment Labels, which use a 55% city and 45% highway weighting for combined fuel economy and CO_2 values. When data for these vehicles is integrated into the data for the rest of the report, the adjusted highway and city values are combined using a 43% city and 57% highway weighting (see Section 10 for a detailed explanation). Additionally, some PHEV calculations are also adjusted, as explained at the end of this section.

A. MY 2016 VEHICLES

This section will introduce the MY 2016 alternative fuel vehicles that were certified by EPA. For each of these vehicles, the report will introduce key metrics, show how they are determined, and discuss their relevance to consumers and analysts. Table 7.1 shows the alternative fuel vehicles available from OEMs in MY 2016, as well as the powertrain type of each vehicle, inertia weight class (IWT),[7] and footprint. These vehicles constitute a wide array of vehicle designs, sizes, and functions.

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[6] Based on data from the Energy Information Administration, EPA projects that FFVs were fuelled with E85 less than 1 percent of the time in 2008; see 75 Federal Register 14762 (March 26, 2010).
[7] Each inertia weight class represents a range of loaded vehicle weights, or vehicle curb weights plus 300 pounds. Vehicle inertia weight classes are in 250-pound increments for inertia weight classes that are less than 3000 pounds, while inertia weight classes over 3000 pounds are divided into 500-pound increments.

Table 7.1

MY 2016 Alternative Fuel Vehicle Classification and Size

Manufacturer	Model	Fuel or Powertrain	Car or Truck	IWT (lbs)	Footprint (sq ft)
BMW	I3 BEV	EV	Car	3000	43.3
Fiat-Chrysler	500e	EV	Car	3000	34.8
Ford	Focus	EV	Car	4000	43.7
GM	Spark	EV	Car	3000	36.1
Kia	Soul	EV	Car	3500	43.7
Mercedes	B250e	EV	Car	4000	44.7
Mercedes	Smart Fortwo	EV	Car	2250	26.8
Mitsubishi	i-MiEV	EV	Car	2750	26.8
Nissan	Leaf	EV	Car	3500	44.6
Tesla	Model S	EV	Car	4500	53.6
Tesla	Model S AWD	EV	Car	5000	53.6
Tesla	Model X AWD	EV	Truck	5500	53.6
VW	e-Golf	EV	Car	3500	43.2
BMW	330e	PHEV	Car	4000	47.3
BMW	I3 REX	PHEV	Car	3500	43.3
BMW	I8	PHEV	Car	3500	50.7
BMW	X5 xDrive40e	PHEV	Truck	5500	50.0
Ford	C-MAX	PHEV	Car	4000	44.0
Ford	Fusion	PHEV	Car	4000	48.7
GM	ELR	PHEV	Car	4000	46.1
GM	Volt	PHEV	Car	4000	45.1
Hyundai	Sonata	PHEV	Car	4000	48.0
Mercedes	S 550e	PHEV	Car	5500	55.6
Volvo	XC90 AWD	PHEV	Truck	5500	53.5
VW	A3 e-tron	PHEV	Car	4000	43.4
VW	Cayenne S	PHEV	Truck	6000	51.8
VW	Panamera S	PHEV	Car	5000	51.8
GM	Impala Dual Fuel	CNG	Car	4500	48.3
Hyundai	Tucson	FCV	Car	4500	45.2
Toyota	Mirai	FCV	Car	4000	46.0

As shown in Table 7.1, there are twelve EVs available in MY 2016, fourteen PHEVs, two hydrogen fuel cell vehicles, and one dual fuel CNG vehicle. This is the first year this report has included fuel cell vehicles. For the first time in many years, there are no dedicated CNG vehicles being offered for MY 2016. In some cases, there are several variants of an individual model available (e.g. Tesla S). For this report, all of those variants are counted as one model, but each variation may be shown separately in the tables in this section due to differences in weight and performance.

The list of vehicles in Table 7.1 shows a wide range of vehicles, including three trucks. The footprint of the largest vehicle, the Mercedes S 550e, is more than double that of the smallest vehicle, which is the Smart Fortwo. The weight range of MY 2016 AFVs also significantly varies, from an IWT of 2250 to 6000.

This report has not previously tracked or analyzed data on the range of vehicles using petroleum fuels because gasoline and diesel vehicles can generally travel at least 300 miles without refueling, and gasoline and diesel fuel stations are common and well distributed across the United States (although there are some rural areas where range may in fact be an important consideration). Most alternative fuel vehicles have lower vehicle range than gasoline and diesel vehicles, when operated on the alternative fuel, and all alternative fuel vehicles are likely to have more limited public refueling infrastructure. Range is of particular concern with electric vehicles, as most EVs have a range that is considerably less than that of comparable petroleum-fueled vehicles. The availability of dedicated EV charging stations is also currently limited, especially for stations powerful enough to be capable of "fast" charging.[8] For each of the vehicles listed in Table 7.1, Table 7.2 shows the label driving range for alternative fuel vehicles when operating on the alternative fuel, total electricity plus gasoline range for PHEVs, and introduces the concept of a utility factor for PHEVs (explained below).

PHEVs blend EV technology with more familiar powertrain technology from petroleum-fueled vehicles. Current PHEVs feature both an electric drive system designed to be charged from an electricity source external to the vehicle (like an EV), and a gasoline internal combustion engine. There are generally three ways that a PHEV can operate:

1. Charge depleting electric only mode – In electric only mode the vehicle operates like an EV, using only energy stored in the battery to propel the vehicle.

2. Charge depleting blended mode – In blended mode the vehicle uses both energy stored in the battery and energy from the gasoline tank to propel the vehicle. Depending on the vehicle design and driving conditions, blended operation can include substantial all-electric driving.

3. Charge sustaining mode – In charge sustaining mode, the PHEV has exhausted the external energy from the electric grid that is stored in the battery and relies on the gasoline internal combustion engine. In charge sustaining mode, the vehicle will operate much like a traditional hybrid.

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[8] While dedicated EV charging stations are currently limited, electricity is available in nearly all but the most remote parts of the country. EVs can generally be recharged from a standard 110v outlet although charging will be slower than at a dedicated 220v charging station.

Table 7.2

MY 2016 Alternative Fuel Vehicle Powertrain and Range

Manufacturer	Model	Fuel or Powertrain	Alternative Fuel Range miles *	Total Range miles	Utility Factor
BMW	I3 BEV	EV	81	81	-
Fiat-Chrysler	500e	EV	84	84	-
Ford	Focus	EV	76	76	-
GM	Spark	EV	82	82	-
Kia	Soul	EV	93	93	-
Mercedes	B250e	EV	87	87	-
Mercedes	Smart Fortwo	EV	68	68	-
Mitsubishi	i-MiEV	EV	62	62	-
Nissan	Leaf 24 kWh	EV	84	84	-
Nissan	Leaf 30 kWh	EV	107	107	-
Tesla	Model S 60 kWh	EV	210	210	-
Tesla	Model S 70 kWh	EV	234	234	-
Tesla	Model S 75 kWh	EV	249	249	-
Tesla	Model S 85 kWh	EV	265	265	-
Tesla	Model S 90 kWh	EV	265	265	-
Tesla	Model S AWD 60D	EV	218	218	-
Tesla	Model S AWD 70D	EV	240	240	-
Tesla	Model S AWD 75D	EV	259	259	-
Tesla	Model S AWD 85D	EV	270	270	-
Tesla	Model S AWD 90D	EV	294	294	-
Tesla	Model S AWD P85D	EV	253	253	-
Tesla	Model S AWD P90D	EV	250	250	-
Tesla	Model X AWD 75D	EV	238	238	-
Tesla	Model X AWD 90D	EV	257	257	-
Tesla	Model X AWD P90D	EV	250	250	-
VW	e-Golf	EV	83	83	-
BMW	330e	PHEV	14	350	0.46
BMW	I3 REX	PHEV	72	150	0.83
BMW	I8	PHEV	15	330	0.37
BMW	X5 xDrive40e	PHEV	14	540	0.35
Ford	C-MAX	PHEV	20	550	0.45
Ford	Fusion	PHEV	20	550	0.45
GM	ELR	PHEV	40	340	0.68
GM	ELR Sport	PHEV	36	320	0.64
GM	Volt	PHEV	53	420	0.76
Hyundai	Sonata	PHEV	27	600	0.56
Mercedes	S 550e	PHEV	14	450	0.35
Volvo	XC90 AWD	PHEV	14	350	0.34
VW	A3 e-tron	PHEV	16	380	0.39
VW	A3 e-tron ultra	PHEV	17	430	0.41
VW	Cayenne S	PHEV	14	480	0.37
VW	Panamera S	PHEV	16	560	0.39
GM	Impala Dual Fuel	CNG	119	487	N/A
Hyundai	Tucson	FCV	265	265	-
Toyota	Mirai	FCV	312	312	-

* Many PHEVs are capable of operating in blended mode and may use some gasoline to achieve the given alternative fuel range.

The presence of both electric drive and an internal combustion engine results in a complex system that can be used in many different combinations, and manufacturers are choosing to operate PHEV systems in different ways. This complicates direct comparisons among PHEV models in this report. For each MY 2016 PHEV, Table 7.2 shows the estimated range on alternative fuel and estimated total range. For PHEVs like the Chevrolet Volt, which cannot operate in blended mode, the alternative fuel range represents the estimated range operating in electric only mode. However, for PHEVs that operate in a blended mode, the alternative fuel range represents the estimated range of the vehicle operating in either electric only *or* blended mode, due to the design of the vehicle. For example, the Porsche Panamera PHEV uses electricity stored in its battery and a small amount of gasoline to achieve an alternative fuel range of 11 miles. The C-Max and Fusion PHEVs did not use any gasoline to achieve an alternative fuel range of 20 miles on EPA test cycles; however, certain driving conditions (e.g., more aggressive accelerations, higher speeds, and air conditioning or heater operation) would likely cause these vehicles to operate in a blended mode instead of an all-electric mode. Table 7.2 also introduces the concept of a utility factor. The utility factor is directly related to the electric range for PHEVs, and is a projection, on average, of the percentage of miles that will be driven using electricity (in electric only and blended modes) by an average driver.

Table 7.3 shows five energy-related metrics for the MY 2016 alternative fuel vehicles (no entry is shown if the metric is not applicable to that vehicle technology). These data are generally included on the EPA/NHTSA Fuel Economy and Environment labels beginning in MY 2013. Comparing the energy or fuel efficiency performance from alternative fuel vehicles raises complex issues of how to compare different fuels. For example, consumers and OEMs are familiar and comfortable with evaluating gasoline and diesel vehicle fuel economy in terms of miles per gallon, and it is the primary efficiency metric in this report. To enable this comparison for alternative fuel vehicles, the fuel efficiency of vehicles operating on electricity, hydrogen, and CNG are evaluated in terms of miles per gallon of gasoline equivalent (an energy metric described in more detail below).

The fourth column in Table 7.3 gives electricity consumption rates for EVs and PHEVs. The units for electricity consumption are kilowatt-hours per 100 miles (kW-hrs/100 miles). As shown on the vehicle label, the electricity consumption rate is based on the amount of electricity required from an electric outlet to charge the vehicle and includes wall-to-vehicle charging losses. The values for all of the EVs and PHEVs reflect the electricity consumption rate required to operate the vehicle in either electric-only or blended mode operation. PHEVs that are capable of operating in a blended mode may also consume some gasoline in addition to electricity. Any additional gasoline used is shown in the fifth column. For example, the Porsche Panamera PHEV consumes 69 kWh and 0.5 gallons of gasoline per 100 miles during this combination of electric-only and blended modes.

Table 7.3

MY 2016 Alternative Fuel Vehicle Fuel Economy Label Metrics

| Manufacturer | Model | Fuel or Powertrain | Charge Depleting | | | Charge Sustaining | Overall |
			Electricity (kW-hrs/ 100 miles)	Gasoline (gallons/ 100 miles)	Fuel Economy (mpge)	Fuel Economy (mpg)	Fuel Economy (mpge)
BMW	I3 BEV	EV	27	-	124	N/A	124
Fiat-Chrysler	500e	EV	30	-	112	N/A	112
Ford	Focus	EV	32	-	105	N/A	105
GM	Spark	EV	28	-	119	N/A	119
Kia	Soul	EV	32	-	105	N/A	105
Mercedes	B250e	EV	40	-	84	N/A	84
Mercedes	Smart Fortwo	EV	32	-	107	N/A	107
Mitsubishi	i-MiEV	EV	30	-	112	N/A	112
Nissan	Leaf 24 kWh	EV	30	-	114	N/A	114
Nissan	Leaf 30 kWh	EV	30	-	112	N/A	112
Tesla	Model S 60 kWh	EV	34	-	99	N/A	99
Tesla	Model S 70 kWh	EV	38	-	89	N/A	89
Tesla	Model S 75 kWh	EV	32	-	98	N/A	98
Tesla	Model S 85 kWh	EV	38	-	89	N/A	89
Tesla	Model S 90 kWh	EV	38	-	89	N/A	89
Tesla	Model S AWD 60D	EV	32	-	104	N/A	104
Tesla	Model S AWD 70D	EV	33	-	101	N/A	101
Tesla	Model S AWD 75D	EV	32	-	103	N/A	103
Tesla	Model S AWD 85D	EV	34	-	100	N/A	100
Tesla	Model S AWD 90D	EV	33	-	103	N/A	103
Tesla	Model S AWD P85D	EV	36	-	93	N/A	93
Tesla	Model S AWD P90D	EV	38	-	89	N/A	89
Tesla	Model X AWD 75D	EV	36	-	93	N/A	93
Tesla	Model X AWD 90D	EV	37	-	92	N/A	92
Tesla	Model X AWD P90D	EV	38	-	89	N/A	89
VW	e-Golf	EV	29	-	116	N/A	116
BMW	330e	PHEV	47	0.0	72	31	38
BMW	I3 REX	PHEV	29	-	117	39	88
BMW	I8	PHEV	43	0.1	76	28	37
BMW	X5 xDrive40e	PHEV	59	0.0	56	24	29
Ford	C-MAX	PHEV	37	0.0	88	38	51
Ford	Fusion	PHEV	37	0.0	88	38	51
GM	ELR	PHEV	39	-	85	32	55
GM	ELR Sport	PHEV	43	-	80	30	50
GM	Volt	PHEV	31	-	106	42	77
Hyundai	Sonata	PHEV	34	0.0	99	40	59
Mercedes	S 550e	PHEV	59	0.0	58	26	31
Volvo	XC90 AWD	PHEV	58	0.1	53	25	30
VW	A3 e-tron	PHEV	40	0.0	83	35	44
VW	A3 e-tron ultra	PHEV	38	0.0	86	39	49
VW	Cayenne S	PHEV	69	-	47	22	27
VW	Panamera S	PHEV	51	0.5	51	25	31
GM	Impala Dual Fuel	CNG	N/A	N/A	N/A	N/A	N/A*
Hyundai	Tucson	FCV	N/A	N/A	N/A	N/A	50
Toyota	Mirai	FCV	N/A	N/A	N/A	N/A	67

* The Impala Dual Fuel vehicle has fuel economy of 19 mpge on CNG and 20 mpg on gasoline

The sixth column simply converts the electricity consumption data in the fourth column and the gasoline consumption data in the fifth column into a combined miles per gallon of gasoline-equivalent (mpge) metric. The mpge metric is a measure of the miles the vehicle can travel on an amount of energy that is equal to the amount of energy stored in a gallon of gasoline. For a vehicle operating on electricity, mpge is simply calculated as 33.705 kW-hrs/gallon divided by the vehicle electricity consumption in kW-hrs/mile. For example, for the Leaf, 33.705 kW-hrs/gallon divided by 0.30 kW-hrs/mile, which is equivalent to 30 kW-hrs/100 miles, is 114 mpge.[9] Because the Porsche Panamera PHEV consumes both electricity and gasoline over the alternative fuel range of 14 miles, the electric consumption value of 47 mpge includes both the electricity and gasoline consumption, at a rate of 69 kW-hrs/100 miles of electricity and 0.5 gal/100 miles of gasoline.

The seventh column gives label fuel economy values for vehicles operating on gasoline only, which is relevant here only for the PHEVs operating in charge sustaining mode. For PHEVs, the EPA/NHTSA label shows both electricity consumption in kW-hrs/100 miles and mpge, when the vehicle operates exclusively on electricity or in a blended mode, and gasoline fuel economy in mpg, when the vehicle operates exclusively on gasoline.

The final column gives the overall mpge values reflecting the overall energy efficiency of the vehicle on all of the fuels on which the vehicle can operate. While mpge does not reflect how all alternative fuels are sold (natural gas is in fact sold in gallons of gasoline equivalent, but electricity is not), it does provide a common metric with which to compare fuels that are sold in different units, and mpge is generally included on the EPA/NHTSA labels for that reason. For PHEVs, the mpge metric can also be used to determine the overall equivalent fuel economy for a vehicle that operates on two unique fuels. In addition to the energy metrics in the previous columns, the one key additional parameter necessary to calculate a combined electricity/gasoline mpge value for a PHEV is the utility factor that was introduced in Table 7.2. The MY 2016 Volt, for example, has a utility factor of 0.76, i.e., it is expected that, on average, the Volt will operate 76% of the time on electricity and 24% of the time on gasoline. Utility factor calculations are based on an SAE methodology that EPA has adopted for regulatory compliance (SAE 2010). For EVs and fuel cell vehicles, the last column simply reports the mpge values that are on the EPA/NHTSA label.

Tables 7.4 and 7.5 show several key CO_2 emissions metrics for MY 2016 alternative fuel vehicles.

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[9] The actual calculations were done with unrounded numbers. Using the rounded numbers provided here may result in a slightly different number due to rounding error.

Table 7.4

MY 2016 Alternative Fuel Vehicle Label Tailpipe CO_2 Emissions Metrics

Manufacturer	Model	Fuel or Powertrain	Tailpipe CO_2 (g/mile)
BMW	I3 BEV	EV	0
Fiat-Chrysler	500e	EV	0
Ford	Focus	EV	0
GM	Spark	EV	0
Kia	Soul	EV	0
Mercedes	B250e	EV	0
Mercedes	Smart Fortwo	EV	0
Mitsubishi	i-MiEV	EV	0
Nissan	Leaf	EV	0
Tesla	Model S	EV	0
Tesla	Model S AWD	EV	0
Tesla	Model X AWD	EV	0
VW	e-Golf	EV	0
BMW	330e	PHEV	184
BMW	I3 REX	PHEV	37
BMW	I8	PHEV	198
BMW	X5 xDrive40e	PHEV	247
Ford	C-MAX	PHEV	129
Ford	Fusion	PHEV	129
GM	ELR	PHEV	91
GM	ELR Sport	PHEV	104
GM	Volt	PHEV	51
Hyundai	Sonata	PHEV	101
Mercedes	S 550e	PHEV	227
Volvo	XC90 AWD	PHEV	241
VW	A3 e-tron	PHEV	158
VW	A3 e-tron ultra	PHEV	138
VW	Cayenne S	PHEV	260
VW	Panamera S	PHEV	229
GM	Impala Dual Fuel	CNG	N/A*
Hyundai	Tucson	FCV	0
Toyota	Mirai	FCV	0

* The Impala Dual Fuel vehicle has emissions of 343 g/mile on CNG and 437 g/mile on gasoline

Table 7.4 gives vehicle tailpipe CO_2 emissions values. EPA and vehicle manufacturers have been measuring tailpipe emissions since the early 1970s using standardized laboratory tests. Table 7.4 gives tailpipe CO_2 emissions values that are included on the EPA/DOT Fuel Economy and Environment labels (and reflected in the label's Greenhouse Gas Rating) that are currently used for advanced technology vehicles. These label values reflect EPA's best estimate of the CO_2 tailpipe emissions that these vehicles will produce, on average, in real world city and highway operation based on the EPA 5-cycle label methodology and using a 55% city/45% highway weighting. EVs, of course, have no tailpipe emissions. For the PHEVs, the label CO_2 emissions values utilize the same utility factors discussed above to weight the CO_2 emissions on electric and gasoline operation. For natural gas vehicles, these values are based on vehicle test data and our 5-cycle methodology. It is important to note that, to be

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consistent with CO_2 emissions data elsewhere in this report, the tailpipe CO_2 emissions values given in Table 7.4 for CNG vehicles do not account for the higher global warming potency associated with methane emissions, which have the potential to be higher for CNG vehicles.

Table 7.5 accounts for the "upstream" CO_2 emissions associated with the production and distribution of electricity used in EVs and PHEVs. Gasoline and diesel fuels also have CO_2 emissions associated with their production and distribution, but these upstream emissions are not reflected in the tailpipe CO_2 emissions values discussed elsewhere in this report. Combining vehicle tailpipe and fuel production/distribution sources, gasoline vehicles emit about 80 percent of total CO_2 emissions at the vehicle tailpipe with the remaining 20 percent of total CO_2 emissions associated with upstream fuel production and distribution. Diesel fuel has a similar approximate relationship between tailpipe and upstream CO_2 emissions. Hydrogen and CNG vehicle upstream CO_2 emissions data is not included in Table 7.5.[10] On the other hand, vehicles powered by grid electricity emit no CO_2 (or other emissions) at the vehicle tailpipe; therefore all CO_2 emissions associated with an EV are due to fuel production and distribution. Depending on how the electricity is produced, these fuels can have very high fuel production/distribution CO_2 emissions (for example, if coal is used with no CO_2 emissions control) or very low CO_2 emissions (for example, if renewable processes with minimal fossil energy inputs are used).

An additional complicating factor in Table 7.5 is that electricity production in the United States varies significantly from region to region. Hydroelectric plants provide a large percentage of electricity in the northwest, coal-fired power plants produce the majority of electricity in the Midwest, and natural gas has increased its electricity market share in many regions of the country. Nuclear power plants and renewable energy make up the balance of U.S. electricity production. In order to bracket the possible GHG emissions impact, Table 7.5 provides ranges with the low end of the range corresponding to the California powerplant GHG emissions factor, the middle of the range represented by the national average powerplant GHG emissions factor, and the upper end of the range corresponding to the powerplant GHG emissions factor for the Rockies.

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[10] There is considerable uncertainly and ongoing research on the topic of GHG emissions from natural gas production, particularly with respect to hydraulic fracturing ("fracking") processes. Hydrogen can be created using multiple pathways, each with with varying GHG emissions.

Table 7.5

MY 2016 Alternative Fuel Vehicle Upstream CO₂ Emission Metrics

Manufacturer	Model	Fuel or Powertrain	Tailpipe + Total Upstream CO₂ Low (g/mile)	Avg (g/mile)	High (g/mile)	Tailpipe + Net Upstream CO₂ Low (g/mile)	Avg (g/mile)	High (g/mile)
BMW	I3 BEV	EV	93	159	243	25	91	175
Fiat-Chrysler	500e	EV	103	177	270	39	112	206
Ford	Focus	EV	110	188	288	41	120	220
GM	Spark	EV	96	165	252	32	101	188
Kia	Soul	EV	110	188	288	41	120	220
Mercedes	B250e	EV	137	236	360	67	166	290
Mercedes	Smart Fortwo	EV	110	188	288	45	124	224
Mitsubishi	i-MiEV	EV	103	177	270	39	112	206
Nissan	Leaf 24 kWh	EV	103	177	270	33	107	200
Nissan	Leaf 30 kWh	EV	103	177	270	33	107	200
Tesla	Model S 60 kWh	EV	117	200	306	34	117	223
Tesla	Model S 70 kWh	EV	130	224	342	47	141	259
Tesla	Model S 75 kWh	EV	110	188	288	27	105	205
Tesla	Model S 85 kWh	EV	130	224	342	47	141	259
Tesla	Model S 90 kWh	EV	130	224	342	47	141	259
Tesla	Model S AWD 60D	EV	110	188	288	27	105	205
Tesla	Model S AWD 70D	EV	113	194	297	30	111	214
Tesla	Model S AWD 75D	EV	110	188	288	27	106	205
Tesla	Model S AWD 85D	EV	117	200	306	34	117	223
Tesla	Model S AWD 90D	EV	113	194	297	30	111	214
Tesla	Model S AWD P85D	EV	123	212	324	40	129	241
Tesla	Model S AWD P90D	EV	130	224	342	47	141	259
Tesla	Model X AWD 75D	EV	123	212	324	30	119	231
Tesla	Model X AWD 90D	EV	127	218	333	34	125	240
Tesla	Model X AWD P90D	EV	130	224	342	37	131	249
VW	e-Golf	EV	99	171	261	32	103	193
BMW	330e	PHEV	305	358	426	225	278	346
BMW	I3 REX	PHEV	129	189	264	63	123	198
BMW	I8	PHEV	303	342	392	224	263	313
BMW	X5 xDrive40e	PHEV	379	429	492	286	336	400
Ford	C-MAX	PHEV	218	259	311	155	196	248
Ford	Fusion	PHEV	218	259	311	152	193	245
GM	ELR	PHEV	204	269	351	133	198	280
GM	ELR Sport	PHEV	224	292	378	152	220	306
GM	Volt	PHEV	145	203	276	78	136	210
Hyundai	Sonata	PHEV	191	238	296	124	171	230
Mercedes	S 550e	PHEV	355	406	471	268	319	384
Volvo	XC90 AWD	PHEV	370	419	481	278	327	389
VW	A3 e-tron	PHEV	251	290	339	185	224	273
VW	A3 e-tron ultra	PHEV	226	264	313	164	202	250
VW	Cayenne S	PHEV	412	474	552	313	376	454
VW	Panamera S	PHEV	355	405	467	266	316	378
	Average Car		**381**	**381**	**381**	**305**	**305**	**305**

Based on data from EPA's eGRID powerplant database (Abt Associates 2015), and accounting for additional greenhouse gas emissions impacts for feedstock processing upstream of the powerplant (Argonne 2015), EPA estimates that the electricity CO_2 emission factors for various regions of the country vary from 343 g CO_2/kW-hr in California to 900 g CO_2/kW-hr in the Rockies, with a national average of 589 g CO_2/kW-hr. Emission rates for small regions in upstate New York and Alaska have lower electricity upstream CO_2 emission rates than California. However, California is a good surrogate for the "low" end of the range because California is a leading market for current EVs and PHEVs. Initial sales of electric vehicles have been largely, though not exclusively, focused in regions of the country with powerplant CO_2 emissions factors lower than the national average, such as California, New York, and other coastal areas. Accordingly, in terms of CO_2 emissions, EPA believes that the current "sales-weighted average" vehicle operating on electricity in the near term will likely fall somewhere between the low end of this range and the national average.[11]

The fourth through sixth columns in Table 7.5 provide the range of tailpipe plus *total* upstream CO_2 emissions for EVs and PHEVs based on regional electricity emission rates. For comparison, the average MY 2015 car is also included in Table 7.5. The methodology used to calculate the range of tailpipe plus total upstream CO_2 emissions for EVs, is shown in the following example for the MY 2015 Nissan Leaf:

- Start with the label (5-cycle values weighted 55% city/45% highway) vehicle electricity consumption in kW-hr/mile, which for the Leaf is 30 kW-hr/100 miles, or 0.30 kW-hr/mile

- Determine the regional powerplant emission rate, regional losses during electricity distribution, and the additional regional emissions due to fuel production upstream of the powerplant (for California, these numbers are 295 g/kW-hr, 5.8%, and 9.5%).

- Determine the regional upstream emission factor (for California 295 g/kW-hr / (1-0.058) * (1+0.095) = 343 g CO_2/kW-hr)[12]

- Multiply by the range of Low (California = 343 g CO_2/kW-hr), Average (National Average = 589 g CO_2/kW-hr), and High (Rockies = 900 g CO_2/kW-hr) electricity upstream CO_2 emission rates, which yields a range for the Leaf of 103-270 grams CO_2/mile.

The tailpipe plus total upstream CO_2 emissions values for PHEVs include the upstream CO_2 emissions due to electricity operation and both the tailpipe and upstream CO_2 emissions due to gasoline operation, using the utility factor discussed above to weight the values for electricity and gasoline operation. The tailpipe plus total upstream CO_2 emissions values for the average car are the average adjusted MY 2016 car tailpipe CO_2 emissions (from Table 4.3) multiplied by 1.25 to account for upstream emissions due to gasoline production.

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[11] To estimate the upstream greenhouse gas emissions associated with operating an EV or PHEV in a specific geographical area, use the emissions calculator at www.fueleconomy.gov/feg/Find.do?action=bt2.
[12] The actual calculations were done with unrounded numbers. Using the rounded numbers provided here may result in a slightly different number due to rounding error.

The values in columns four through six are tailpipe plus *total* upstream CO_2 emissions. But, all of the gasoline and diesel vehicle CO_2 emissions data in the rest of this report refer to tailpipe only emissions and do not reflect the upstream emissions associated with gasoline or diesel production and distribution. Accordingly, in order to equitably compare the overall relative impact of EVs and PHEVs with tailpipe emissions of petroleum-fueled vehicles, EPA uses the metric "tailpipe plus *net* upstream emissions" for EVs and PHEVs (note that this same approach has been adopted for EV and PHEV regulatory compliance with the 2012-2025 light-duty vehicle GHG emissions standards for sales of EVs and PHEVs in MY 2012-2016 and MY 2022-2025 that exceed sales thresholds). The net upstream emissions for an EV is equal to the total upstream emissions for the EV minus the upstream emissions that would be expected from a comparable-sized (size is a good first-order measure for utility and footprint is the size-based metric used for standards compliance) gasoline vehicle. The net upstream emissions for PHEVs are equal to the net upstream emissions of the PHEV due to electricity consumption in electric or blended mode multiplied by the utility factor. The net upstream emissions for a gasoline vehicle are zero.

For each EV or PHEV, the upstream emissions for a comparable gasoline vehicle are determined by first using the footprint based compliance curves to determine the CO_2 compliance target for a vehicle with the same footprint. Since upstream emissions account for approximately 20% of total CO_2 emissions for gasoline vehicles, the upstream emissions for the comparable gasoline vehicle are equal to one fourth of the tailpipe-only compliance target.

The final three columns of Table 7.5 give the tailpipe plus net upstream CO_2 values for EVs and PHEVs using the same Low, Average, and High electricity upstream CO_2 emissions rates discussed above. These values bracket the possible real world net CO_2 emissions that would be associated with consumer use of these vehicles. For the Leaf, these values are simply the values in columns four through six minus the upstream GHG emissions of a comparably sized gasoline vehicle. Based on the MY 2016 CO_2 footprint curve, the 5-cycle tailpipe GHG emissions for a Leaf-sized gasoline vehicle meeting its compliance target would be close to 279 grams/mi, with upstream emissions of one-fourth of this value, or 70 g/mi. The net upstream for the Leaf are determined by subtracting this value, 70 g/mi, from the total (tailpipe + total upstream) emissions for the Leaf. The result is a range for the tailpipe plus net upstream value of 33-200 g/mile as shown in Table 7.5, with a more likely sales-weighted value in the 33-107 g/mi range.

For PHEVs, the tailpipe plus net upstream emissions values use the utility factor values discussed above to weight the individual values for electric operation and gasoline operation.

While there are still relatively few OEM AFVs in MY 2016, the total production of AFVs is projected to continue to increase. This report will continue to track the metrics presented in this section and report on trends in AFV CO_2 emissions and fuel economy as more models are introduced and more data becomes available in future years.

B. ALTERNATIVE AFV METRICS

Determining metrics for AFVs that are meaningful and accurate is challenging. In particular, vehicles that are capable of using dual fuels, such as PHEVs, can have complicated modes of operation that make it difficult to determine meaningful metrics. In this section, we have reported and discussed several metrics that are used on the EPA/DOT Fuel Economy and Environment Labels and in a regulatory context, namely "mpge," tailpipe CO_2 emissions, and net upstream GHG emissions. There are, however, other ways that AFV operation can be quantified.

Other energy metric options that could be considered include 1) mpge plus net fuel life-cycle energy, which would also reflect differences in upstream energy consumption in producing the alternative fuel relative to gasoline-from-oil; and 2) miles per gallon of petroleum, which would only count petroleum use and not other forms of energy. Compared to mpge, using the mpge plus net fuel life-cycle energy metric would generally result in lower numerical fuel economy values, and using the miles per gallon of petroleum metric would yield higher fuel economy values.

C. ADDITIONAL NOTE ON PHEV CALCULATIONS

Calculating fuel economy and CO_2 emission values for PHEVs is a complicated process, as discussed in this section. The examples given for individual vehicles were based on calculations behind the EPA/DOT Fuel Economy and Environment Labels. In addition to the approach used for the labels, there are multiple methods for determining utility factors depending on the intended use of the value. The standardized utility factor calculations are defined in the Society of Automobile Engineers (SAE) document SAE J2841.

The utility factors that are used for fleetwide calculations are somewhat different than those used to create label values. For label values, multi-day individual utility factors (MDIUF) are used to incorporate "a driver's day to day variation into the utility calculation." For fleetwide calculations, fleet utility factors (FUF) are applied to "calculate the expected fuel and electric consumption of an entire fleet of vehicles." Since the Trends report is generally a fleetwide analysis, the FUF utility factors were applied, instead of the MDIUF utility factors, when the data was integrated with the rest of the fleet data. Additionally, since Trends uses a 43% city, 57% highway weighting for combining adjusted fuel economy and CO_2 data, the FUF utility factors created for Trends were based on that weighting, not on 55% city, 45% highway weighting used on labels (see section 10 for a discussion of city and highway weighting).

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8 High Fuel Economy/Low CO₂ and Advanced Technology Choices

Consumers shopping for vehicles with comparatively high fuel economy and low tailpipe CO_2 emissions have more vehicles to choose among in MY 2016 than MY 2011. These choices reflect a more diverse range of technology packages on conventional gasoline and diesel vehicles as well as an increasing number of alternative fuel vehicle offerings. Section 5 analyzes important trends for a number of vehicle technologies. Section 7 provides data on individual alternative fuel vehicle models such as electric vehicles, plug-in hybrid electric vehicles, compressed natural gas vehicles, and hydrogen fuel cell vehicles. This section focuses specifically on trends related to the fuel economy and advanced vehicle purchase choices available to consumers in the new vehicle market.

A. METHODOLOGY

There are some important methodological differences in the analysis in this section relative to Sections 1-6. First, the data in this section are not weighted by vehicle production levels, but instead reflect "model counts," which is more appropriate for evaluating vehicle choices for consumers. This is because, to an individual consumer in the market for a new vehicle, it makes little or no difference if a particular model has high or low production. Second, the analysis in this section focuses on the changes between MY 2011 and MY 2016, rather than trends over multiple decades. These two model years are used because a 5-year period is long enough to identify meaningful multi-year trends.

This "model count" analysis requires assumptions about how to define a model. Our objective in this analysis is to count models that are generally marketed and perceived by consumers to be unique vehicle choices, but not to count multiple configurations that are generally marketed and perceived by consumers to be the same model. The application of this approach requires considerable judgment, and we have made every effort to be consistent for both MY 2011 and MY 2016. The most important guidelines used to classify vehicle configurations into unique "models" for this analysis are:

- Vehicles with the same name are generally counted as one model (e.g., all Honda Civics are counted as one model), with exceptions noted below. Vehicle options included as one model include:
    - Engine and transmission options (including hybrid, diesel, CNG, EV, PHEV, turbo, and ECO variants)
    - 2WD and 4WD versions
    - Trim levels
    - Convertible, hatchback, and wagon body styles
    - FFV and non-FFV models
    - BMW series. For example, all BMW 5 series variants are included as one model, including the ActiveHybrid 5
    - Range Rover and Range Rover Sport

- Generally performance and non-performance vehicles are counted as one model, even if they have distinct names. Vehicle variants counted as one model include:
    - Audi A4 and Audi S4
    - BMW M3 in included in the BMW 3 series
    - Volkswagen Golf and Volkswagen GTI

- Vehicles that are substantially similar, but are marketed and sold by multiple divisions, (often called "twins") are counted as separate models. For example:
    - Ford Escape and Mercury Mariner are counted as separate models
    - Chevrolet Equinox and GMC Terrain are counted as separate models

- Vehicles that are generally marketed as distinct models are counted as separate models. For example:
    - Prius, Prius v and Prius c are counted as distinct models

- The Mini Cooper vehicles are grouped and counted as four models (Mini Cooper, Mini Cooper Roadster, Mini Cooper Clubman, Mini Cooper Countryman/Paceman), generally based on wheelbase, with multiple trim models within each wheelbase counted as the same model

- If at least one variant of an individual model meets a threshold defined in the analysis (e.g., cars with fuel economy greater than 30 mpg), the model is counted only once, regardless of the number of model variants that meet the threshold. For instance, if hybrid, CNG, and gasoline variant Honda Civics exceed 30 mpg, only one Civic is counted as exceeding 30 mpg

These "model count" guidelines resulted in very little difference in the total number of models available to consumers across the industry in MY 2011 and MY 2016: there are approximately 285 models for each year.

Finally, the last methodological difference between this section and most other sections of this report is that two key parameters - vehicle classifications and combined city/highway fuel economy values - are aligned with the Fuel Economy and Environment label in order to be consistent with the information available to consumers when they are considering new vehicle purchases. The vehicle classifications in Figure 8.1 are based on Fuel Economy and Environment label classifications which differ slightly from the definitions of cars and light trucks used in Sections 1-6 in this report (for example, in Figure 8.1, all SUVs are combined into a single category and are not split into car SUVs and truck SUVs as is done for compliance with standards and elsewhere in this report). In this analysis, the label classes are simplified into four broader categories: cars, SUVs, pickups, and minivans/vans (most vehicles labeled as "special purpose vehicles" are shaped like vans and are included in the minivan/van category). If variants of a model were in more than one of these four broader categories, then the variant was counted once in each relevant category. The combined fuel economy values used in Figure 8.1 are based on the 55% city/45% highway weighting used on fuel economy labels, and not on the 43% city/57% highway weighting used for adjusted fuel economy values presented elsewhere in this report. For PHEVs, the mpge value is the combined, utilitized

value. These values can be found in the "Overall Fuel Economy" column of Table 7.3. Data for MY 2016 are preliminary and will be finalized in next year's report.

EPA has updated fuel economy labeling guidance for vehicles beginning in MY 2017. This action may result in small changes to fuel economy values provided on the fuel economy label compared to MY 2016 and earlier vehicles. Data in this year's report do not reflect the 2017 label updates.

B. HIGH FUEL ECONOMY VEHICLE OFFERINGS

Figure 8.1 shows the change from MY 2011[13] to MY 2016 in the number of models for which at least one model variant meets various fuel economy thresholds. The threshold values for EVs, PHEVs, FCVs, and CNG vehicles that are represented in Figure 8.1 use miles per gallon of gasoline-equivalent (mpge), i.e., the miles the vehicle can travel on an amount of electricity, compressed natural gas, or hydrogen that has the same amount of energy as a gallon of gasoline. See Section 7 for a detailed discussion of mpge and electric, plug-in hybrid, compressed natural gas, and hydrogen fuel cell vehicles.

Figure 8.1

Number of Models Meeting Fuel Economy Thresholds in MY 2011 and MY 2016
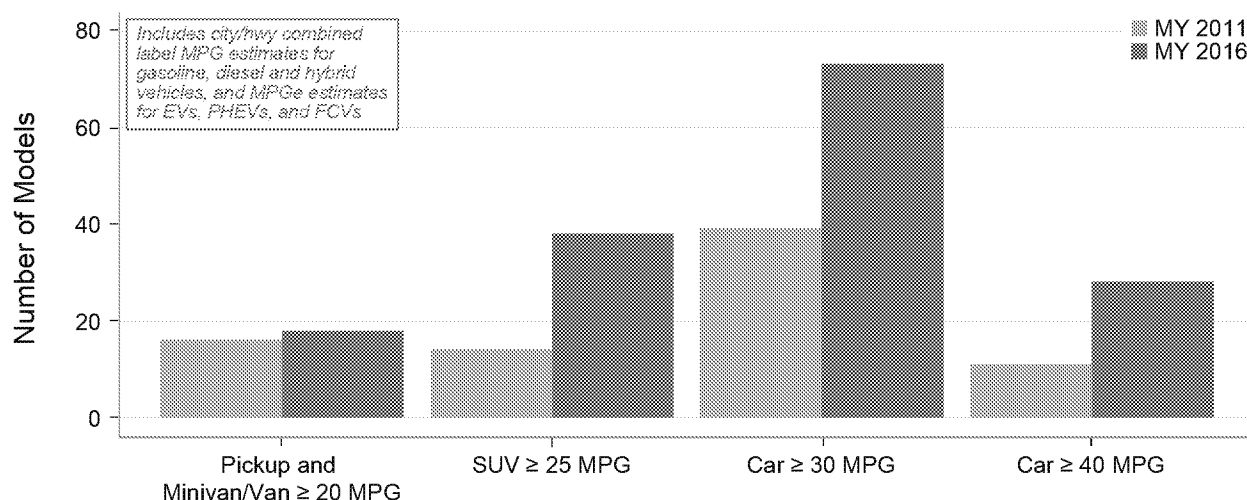
Figure 8.1 shows that there are 18 MY 2016 pickup and minivan/van models for which at least one variant of the model has a combined city/highway label fuel economy rating of 20 mpg or more, a small increase over MY 2011. Eight minivans/vans met or exceeded a 20 mpg threshold in MY 2011, and in MY 2016 ten minivans/vans meet the 20 mpg threshold. While

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[13] The MY 2011 Tesla Roadster electric vehicle is included in the data for figures 8.1 and 8.2. Before MY 2012, manufacturers that produced only EVs were not required to have an EPA fuel economy label; however, for purposes of figure 8.1, the MY 2011 Tesla Roadster is assumed to have fuel economy that is over 40 MPGe and therefore meets the car thresholds for 30 MPGe and 40 MPGe.

the number of minivans/vans meeting or exceeding 20 mpg has increased in the last five years, the number of pickups has remained similar. In MY 2016 there are four small pickups and four standard-sized non-hybrid pickups that cross the 20 mpg threshold (two MY 2016 standard-size pickups also have hybrid versions that crossed the 20 mpg threshold), whereas in MY 2011, the pickups that crossed the 20 MPG thresholds were six small pickups and two hybrid standard-sized pickups.

More than twice as many MY 2016 SUV models achieve 25 mpg or above compared to MY 2011. Of the SUVs that achieved 25 mpg in MY 2011, eleven out of fourteen models had at least one non-hybrid gasoline variant that crossed the threshold. More than 30 non-hybrid, gasoline or diesel SUVs achieve at least 25 mpg in MY 2016, as well as one electric, one hydrogen fuel cell, three PHEV, and eight hybrid SUVs that achieve at least 25 mpg; these total to more than the number of models shown in Figure 8.1 because four of the hybrid, one of the plug-in hybrid electric, and one of the fuel-cell SUVs also have either a diesel or gasoline variant that crosses the 25 MPG threshold.

There are now more than 70 car models available for which at least one variant has a combined city/highway label fuel economy of 30 mpg or more, compared to 39 car models in MY 2011. Of MY 2016 car models that have a combined label value greater than or equal to 30 mpg, more than 40 models reach this threshold with at least one conventional gasoline or diesel variant, compared to 20 models in MY 2011. In addition, more than 25 MY 2016 cars achieve 40 mpg or higher, and 19 of the MY 2016 cars have at least one variant that achieves 50 mpg or higher. All of the MY 2016 cars that achieve at least 40 mpg consist of hybrid electric vehicles, electric vehicles, plug-in hybrid electric vehicles, and fuel cell vehicles. Summing the first three categories for MY 2016 (pickups and minivans/vans >=20 MPG, SUV's >0 25 mpg, and cars >= 30 MPG) yields an increase of about nine models over the sum of the same three categories for MY 2015.

C. ADVANCED TECHNOLOGY VEHICLE OFFERINGS

Figure 8.2 shows that there are a growing number of electric vehicles and plug-in hybrid electric vehicle model. From MY 2011 to MY 2016, the number of EVs has increased from four to twelve, and the number of PHEVs has increased from one to 14. Over the same period, the number of hybrid offerings has increased slightly, and the number of diesel offerings has also increased from eleven to 18. In MY 2011, there were two dedicated CNG vehicles, and in MY 2016 there is one dual-fuel CNG/gasoline vehicle. The number of fuel cell vehicles (FCV) is similar between MY 2011 and MY 2016.[14] For a more detailed discussion of hybrid and diesel vehicles, see Section 5; see Section 7 for more information about alternative fuel vehicles; see section 5C for more details about trends in alternative fuel vehicles.

For Figure 8.2, the "model count" methodology is modified slightly to allow models that have more than one alternative fuel variant to be counted in each alternative fuel category (e.g., a Ford Fusion is available as both an HEV and PHEV, so the model was counted once in each category).

Figure 8.2
Advanced Technology and Alternative Fuel Vehicle Models in MY 2011 and MY 2016

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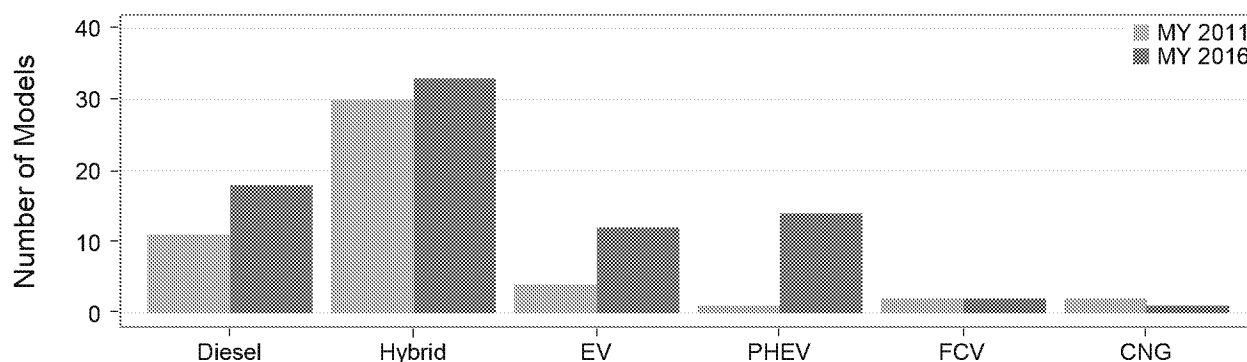
[14] Some advanced technology vehicles are generally available only in selected markets.

9 Regulatory Context

A. PERSONAL VEHICLE FUEL ECONOMY AND GREENHOUSE GAS EMISSIONS STANDARDS

National fuel economy standards have been in place in the United States for cars and light trucks since 1978. The Department of Transportation, through the National Highway Traffic Safety Administration (NHTSA), has the responsibility for setting and enforcing fuel economy standards through the Corporate Average Fuel Economy (CAFE) program. Since the inception of fuel economy standards, EPA has been responsible for establishing fuel economy test procedures and calculation methods, and for collecting data used to determine vehicle fuel economy and manufacturer CAFE levels.

For MY 2012 through 2025, EPA and NHTSA have jointly developed a historic and coordinated National Program, which established EPA greenhouse gas emissions standards and NHTSA CAFE standards that allow manufacturers to build a single national fleet to meet requirements of both programs while ensuring that consumers have a full range of vehicle choices. In 2010, the agencies finalized the first coordinated standards for MY 2012-2016 (75 Federal Register 25324, May 7, 2010). In 2012, the agencies finalized additional coordinated standards for MY 2017-2025 (77 Federal Register 62624, October 15, 2012).[15] These coordinated standards are expected to yield "continuous improvement" reductions in CO_2 emissions and increases in fuel economy levels through MY 2025. EPA is conducting a Midterm Evaluation of the MY 2022-2025 greenhouse gas emissions standards. As the first step in that process, EPA, NHTSA, and the California Air Resources Board released a Draft Technical Assessment Report in July 2016 (see www.epa.gov/regulations-emissions-vehicles-and-engines/midterm-evaluation-light-duty-vehicle-ghg-emissions). As a result of the Midterm Evaluation, EPA will propose a determination to retain the current program, or make it stronger or weaker. Because the NHTSA CAFE standards are augural, NHTSA will conduct a new and full rulemaking in the future to establish standards for MY 2022-2025.

Prior to the National Program, truck CAFE standards began to increase in MY 2005, and have increased every year since. Truck CAFE standards were constant from MY 1996-2004, and car CAFE standards were constant from MY 1990 until MY 2010.

Automaker compliance with CO_2 and CAFE standards is based on unadjusted, laboratory CO_2 and fuel economy values, along with various regulatory incentives and credits, rather than on the adjusted CO_2 and fuel economy values that are used throughout most of this report. Neither unadjusted, laboratory nor adjusted CO_2 and fuel economy values reflect various incentives (e.g., for flexible fuel vehicles for both CO_2 and CAFE standards) and credits (air conditioner and other off-cycle technologies for CO_2 standards) that are available to

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[15] NHTSA's CAFE standards for model years 2022-2025 are not final, and are augural. NHTSA is required by Congress to set CAFE standards for no more than five years at a time.

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manufacturers for regulatory compliance. Adjusted CO2 values are, on average, about 25% higher than the unadjusted, laboratory CO2 values that form the starting point for GHG standards compliance, and adjusted fuel economy values are about 20% lower, on average, than unadjusted fuel economy values that form the starting point for CAFE standards compliance. EPA (at www.epa.gov/regulations-emissions-vehicles-and-engines/ghg-emission-standards-light-duty-vehicles-manufacturer) and NHTSA (at www.nhtsa.gov/Laws-&-Regulations/CAFE---Fuel-Economy) publish separate documents summarizing formal automaker compliance with GHG emissions and CAFE standards.

B. CURRENT VEHICLES THAT MEET FUTURE EPA CO_2 EMISSIONS COMPLIANCE TARGETS

This section evaluates MY 2016 vehicles against future footprint-based CO_2 emission targets to determine which current vehicles could meet or exceed their targets in model years 2020-2025, based on current powertrain designs and only assuming credits for future improvements in air conditioner refrigerants and efficiency. EPA assumed the addition of air conditioning improvements since these are considered to be among the most straightforward and least expensive technologies available to reduce CO_2 and other greenhouse gas emissions.

It is important to note that there are no CO_2 emissions standards for individual vehicles. Overall manufacturer compliance is determined based on the manufacturer specific production-weighted average footprint and CO_2 emissions. Because of this averaging, manufacturers will likely be able to achieve compliance with roughly 50% of their vehicles meeting or exceeding the standards.

Figure 9.1 shows that 17% of projected MY 2016 vehicle production already meets or exceeds the MY 2020 CO_2 targets, with the addition of expected air conditioning improvements. This represents more than 2.5 million vehicles being sold today. The number of MY 2016 vehicles meeting or exceeding the 2020 standards is much higher than projections for earlier model years. In previous reports, EPA projected that 11% of MY 2015 vehicles and 5% of MY 2012 vehicles could meet or exceed 2020 standards.

The bulk of current vehicle production that meets the MY 2020 targets are accounted for by non-hybrid gasoline vehicles, although other technologies, including diesels, hybrids, plug-in hybrid electric vehicles, electric vehicles and hydrogen fuel cell vehicles, are also represented. This is also a significant change from the MY 2012 projections, where the majority of the vehicles meeting the MY 2020 standards were hybrids.

Looking ahead, nearly 3.5% of projected 2016 production already meets the MY 2025 CO_2 targets. Vehicles meeting the MY 2025 CO_2 targets are comprised solely of hybrids, plug-in hybrids, electric vehicles, and fuel cell vehicles. Since the MY 2025 standards are nearly a decade away, there's considerable time for continued improvements in gasoline vehicle technology to occur.

Figure 9.1

MY 2016 Vehicle Production That Meets or Exceeds Future CO$_2$ Emission Targets
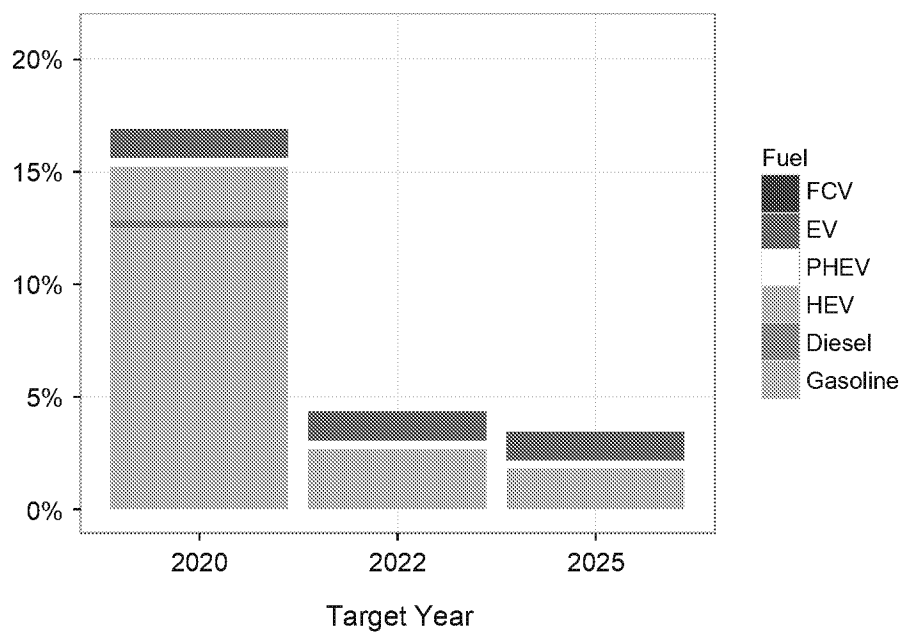
C. Comparison of EPA and NHTSA Fuel Economy Data, 1975-2016

Table 9.1 compares CAFE performance data reported by NHTSA (available at www.nhtsa.gov/CAFE_PIC) with the adjusted and unadjusted, laboratory fuel economy data in this report. With only minor exceptions over 30 years ago, the NHTSA values are higher than the EPA unadjusted, laboratory values, due primarily to alternative fuel vehicle credits, and secondarily to test procedure adjustment factors for cars. In recent years for which both Agencies report final data, the NHTSA values are typically 0.6-1.0 mpg higher than the EPA unadjusted, laboratory values. MY 2013 is the most recent year for which both agencies report final data, and NHTSA's final CAFE performance value is 0.9 mpg higher than EPA's final unadjusted, laboratory value. The NHTSA data from MY 2014 does not include fuel economy values for Hyundai and Kia. The preliminary difference between NHTSA and EPA for MY 2014 is 0.9 mpg, which is consistent with previous years. NHTSA has not yet released projected MY 2015 data or MY 2016 data since that data is not final at this time. Final MY 2015 and 2016 results will be reported when made available by NHTSA.

The individual EPA car, and truck, fuel economy values shown in Table 9.1 for years prior to MY 2011 differ from the values found elsewhere in this report. Beginning with the 2011 report, EPA reclassified many small and mid-sized, 2-wheel drive SUVs from trucks to cars for the entire historical database. This reflects a regulatory change made by NHTSA for CAFE standards beginning in MY 2011 and applies to the joint EPA/NHTSA greenhouse gas emissions and CAFE standards that have been finalized for MY 2012-2025. These changes were not in effect for years prior to MY 2011, and accordingly NHTSA's CAFE fuel economy values prior to MY 2011 are based on the previous car and truck definitions. To enable an apples-to-apples comparison to the NHTSA values, the EPA car and truck values in Table 9.1 through model year 2010 were calculated using the previous car and truck definitions, which is not consistent with the rest of this report. While the individual car and truck values in Table 9.1 are unique, the car and truck definitions do not affect the overall (car plus truck) fuel economy values, which are consistent with the rest of this report.

Table 9.1

Table 9.1

EPA Adjusted, EPA Unadjusted Laboratory, and CAFE Values by Model Year

Model Year	Car				Truck				Both Car and Truck			
	EPA Adj. (MPG)	EPA Unadj., Lab (MPG)	NHTSA CAFE (MPG)	Diff. (NHTSA - Lab) (MPG)	EPA Adj. (MPG)	EPA Unadj., Lab (MPG)	NHTSA CAFE (MPG)	Diff. (NHTSA - Lab) (MPG)	EPA Adj. (MPG)	EPA Unadj., Lab (MPG)	NHTSA CAFE (MPG)	Diff. (NHTSA - Lab) (MPG)
1975	13.5	15.8	N/A	-	11.6	13.7	N/A	-	13.1	15.3	N/A	-
1976	14.9	17.5	N/A	-	12.2	14.4	N/A	-	14.2	16.7	N/A	-
1977	15.6	18.3	N/A	-	13.3	15.6	N/A	-	15.1	17.7	N/A	-
1978	16.9	19.9	19.9	0.0	12.9	15.2	N/A	-	15.8	18.6	19.9	+1.3
1979	17.2	20.3	20.3	0.0	12.5	14.7	18.2	+3.5	15.9	18.7	20.1	+1.4
1980	20.0	23.5	24.3	+0.8	15.8	18.6	18.5	-0.1	19.2	22.5	23.1	+0.6
1981	21.4	25.1	25.9	+0.8	17.1	20.1	20.1	-	20.5	24.1	24.6	+0.5
1982	22.2	26.0	26.6	+0.6	17.4	20.5	20.5	-	21.1	24.7	25.1	+0.4
1983	22.1	25.9	26.4	+0.5	17.8	20.9	20.7	-0.2	21.0	24.6	24.8	+0.2
1984	22.4	26.3	26.9	+0.6	17.4	20.5	20.6	+0.1	21.0	24.6	25.0	+0.4
1985	23.0	27.0	27.6	+0.6	17.5	20.6	20.7	+0.1	21.3	25.0	25.4	+0.4
1986	23.7	27.9	28.2	+0.3	18.2	21.4	21.5	+0.1	21.8	25.7	25.9	+0.2
1987	23.8	28.1	28.5	+0.4	18.3	21.6	21.7	+0.1	22.0	25.9	26.2	+0.3
1988	24.1	28.6	28.8	+0.2	17.9	21.2	21.3	+0.1	21.9	25.9	26.0	+0.1
1989	23.7	28.1	28.4	+0.3	17.6	20.9	21.0	+0.1	21.4	25.4	25.6	+0.2
1990	23.3	27.8	28.0	+0.2	17.4	20.7	20.8	+0.1	21.2	25.2	25.4	+0.2
1991	23.4	28.0	28.4	+0.4	17.8	21.3	21.3	-	21.3	25.4	25.6	+0.2
1992	23.1	27.6	27.9	+0.3	17.4	20.8	20.8	-	20.8	24.9	25.1	+0.2
1993	23.5	28.2	28.4	+0.2	17.5	21.0	21.0	-	20.9	25.1	25.2	+0.1
1994	23.3	28.0	28.3	+0.3	17.2	20.8	20.8	-	20.4	24.6	24.7	+0.1
1995	23.4	28.3	28.6	+0.3	17.0	20.5	20.5	-	20.5	24.7	24.9	+0.2
1996	23.3	28.3	28.5	+0.2	17.2	20.8	20.8	-	20.4	24.8	24.9	+0.1
1997	23.4	28.4	28.7	+0.3	17.0	20.6	20.6	-	20.1	24.5	24.6	+0.1
1998	23.4	28.5	28.8	+0.3	17.1	20.9	21.0	+0.1	20.1	24.5	24.7	+0.2
1999	23.0	28.2	28.3	+0.1	16.7	20.5	20.9	+0.4	19.7	24.1	24.5	+0.4
2000	22.9	28.2	28.5	+0.3	16.9	20.8	21.3	+0.5	19.8	24.3	24.8	+0.5
2001	23.0	28.4	28.8	+0.4	16.7	20.6	20.9	+0.3	19.6	24.2	24.5	+0.3
2002	23.1	28.6	29.0	+0.4	16.7	20.6	21.4	+0.8	19.5	24.1	24.7	+0.6
2003	23.2	28.9	29.5	+0.6	16.9	20.9	21.8	+0.9	19.6	24.3	25.1	+0.8
2004	23.1	28.9	29.5	+0.6	16.7	20.8	21.5	+0.7	19.3	24.0	24.6	+0.6
2005	23.5	29.5	30.3	+0.8	17.2	21.4	22.1	+0.7	19.9	24.8	25.4	+0.6
2006	23.3	29.2	30.1	+0.9	17.5	21.8	22.5	+0.7	20.1	25.2	25.8	+0.6
2007	24.1	30.3	31.2	+0.9	17.7	22.1	23.1	+1.0	20.6	25.8	26.6	+0.8
2008	24.3	30.5	31.5	+1.0	18.2	22.7	23.6	+0.9	21.0	26.3	27.1	+0.8
2009	25.4	32.1	32.9	+0.8	19.0	23.8	24.8	+1.0	22.4	28.2	29.0	+0.8
2010	25.8	32.7	33.9	+1.2	19.1	23.8	25.2	+1.4	22.6	28.4	29.3	+0.9
2011	25.6	32.3	33.1	+0.8	19.1	23.9	24.7	+0.8	22.4	28.1	29.0	+0.9
2012	27.1	34.4	35.4	+1.0	19.3	24.1	25.0	+0.9	23.7	29.9	30.8	+0.9
2013	27.9	35.5	36.4	+0.9	19.8	24.8	25.7	+0.9	24.3	30.7	31.6	+0.9
2014	27.9	35.6	36.7	+1.1	20.4	25.5	26.5	+1.0	24.3	30.7	31.5	+0.8
2015	28.6	36.5			21.1	26.5			24.8	31.4		
2016 (prelim)	*29.0*	*37.1*			*21.4*	*27.0*			*25.6*	*32.5*		

D. Comparison of MY 2015 Unadjusted, Laboratory and Estimated CAFE Data by Manufacturer

The primary differences between EPA unadjusted, laboratory fuel economy data and EPA estimated CAFE values are flexible fuel vehicle (FFV) credits that are available to manufacturers that produce vehicles capable of operation on an alternative fuel (E85, a blend of 85 percent ethanol and 15 percent gasoline), and test procedure adjustment (TPA) credits that apply to manufacturers of passenger cars. Table 9.2 shows how the unadjusted, laboratory fuel economy values in this report, FFV credits, and TPA credits "add up" to estimated CAFE values for each of the thirteen highest volume manufacturers for cars, trucks, and cars plus trucks.

The data for this report, the CAFE compliance program, and EPA's GHG compliance program are all based on data submitted to EPA and NHTSA by automobile manufacturers. The FFV credits, TPA credits, and estimated CAFE values were all obtained directly from the fuel economy compliance program. Alternative fueled vehicles (AFVs) are included in the EPA laboratory and estimated CAFE values, however some AFVs receive additional credits under CAFE that are not accounted for in this report. In most cases the sum of the EPA values shown in this report, the FFV credits, and the TPA credits are within 0.1 mpg of the estimated CAFE value for cars, trucks, and cars and trucks combined. Any discrepancy is largely due to the additional credits for AFVs under CAFE.

The CAFE program recognizes three categories, domestic passenger vehicles, import passenger vehicles, and light trucks and establishes separate compliance requirements for each. The passenger car FFV, TPA, and estimated CAFE numbers in Table 9.2 are calculated from the domestic and import passenger vehicle categories. The truck values were obtained directly (trucks are not eligible for TPA credits). The combined car and truck FFV and TPA credits were generated using car and truck sales. This column is shown for illustrative purposes only, since there are no CAFE standards for combined cars and trucks.

For MY 2015, four of the top 12 manufacturers (excluding VW) earned FFV credits for cars and six manufacturers did so for trucks. For MY 2015, FFV credits are capped at 1.0 mpg for cars and trucks. All manufacturers were eligible for the TPA credits for cars.

Table 9.2

Comparison of MY 2015 EPA Unadjusted, Laboratory and Estimated CAFE (MPG) Values by Manufacturer*

Manufacturer	Passenger Car				Light Truck				Both Car and Truck			
	EPA Unadj., Lab	FFV Credit	TPA Credit	Est. CAFE*	EPA Unadj., Lab	FFV Credit	TPA Credit	Est. CAFE*	EPA Unadj., Lab	FFV Credit	TPA Credit	Est. CAFE*
GM	33.3	0.9	0.2	34.5	24.6	1.0	0.0	25.6	28.0	1.0	0.1	29.1
Toyota	39.2	0.0	0.4	39.6	25.9	0.5	0.0	26.4	32.2	0.4	0.1	32.7
Fiat-Chrysler	32.1	1.0	0.2	33.3	25.2	1.0	0.0	26.2	27.3	1.0	0.1	28.4
Ford	34.4	1.0	0.3	35.8	25.2	1.0	0.0	26.2	28.9	1.0	0.1	30.0
Nissan	40.7	0.0	0.3	41.2	29.0	0.5	0.0	29.5	36.5	0.2	0.2	37.0
Honda	41.0	0.0	0.4	41.4	31.5	0.0	0.0	31.5	37.0	0.0	0.2	37.3
Kia	34.0	0.0	0.4	34.4	27.2	0.0	0.0	27.2	33.4	0.0	0.3	33.7
Hyundai	36.0	0.0	0.4	36.4	27.5	0.0	0.0	27.5	35.3	0.0	0.3	35.6
Subaru	37.0	0.0	0.3	37.2	36.4	0.0	0.0	36.4	36.5	0.0	0.1	36.6
BMW	34.6	0.0	0.3	34.8	28.5	0.0	0.0	28.6	33.2	0.0	0.2	33.3
Mazda	41.4	0.0	0.5	41.9	31.6	0.0	0.0	31.6	38.1	0.0	0.3	38.4
Mercedes	32.5	0.7	0.2	33.4	25.9	0.4	0.0	26.2	29.8	0.5	0.1	30.5

* EPA calculates the CAFE value for each manufacturer and provides to NHTSA per EPCA. NHTSA publishes the final CAFE values in its annual "Summary of Fuel Economy Performance" reports at www.nhtsa.gov/Laws-&-Regulations/CAFE-—-Fuel-Economy.

*Note: Volkswagen is not included in this table due to an ongoing investigation.

10 Additional Database and Report Details

This section addresses several Trends database topics in greater detail. While the key parameters of the Trends database that are of the most importance to users were highlighted in Section 1, this section will help those readers who want to further understand how the database is developed and various nuances associated with the database.

A. SOURCES OF INPUT DATA

Nearly all of the recent model year input for the Trends database is extracted from EPA's current vehicle compliance information system, VERIFY, into which automakers submit data required by congressional statute and EPA regulations. Prior to the beginning of each model year, automakers submit General Label information required to support the generation of the joint EPA/NHTSA Fuel Economy and Environment Labels that appear on all new personal vehicles. Automakers report pre-model year vehicle production projections for individual models to EPA in the General Label submissions; these projections are considered by EPA and automakers to be confidential business information. A few months after the end of each model year, automakers submit Final GHG/CAFE data, which EPA and NHTSA use to determine compliance with GHG emissions and CAFE standards. These end-of-the-year submissions include final production volumes. The production volume levels automakers provide in their Final CAFE reports may differ slightly from their Final GHG reports (less than 0.1%) because the EPA emissions certification regulations, including GHG regulations, require emission compliance in the 50 states, the District of Columbia, Puerto Rico, the Virgin Islands, Guam, American Samoa and the Commonwealth of the Northern Mariana Islands, whereas the CAFE program requires data from the 50 states, the District of Columbia and Puerto Rico only. To maintain consistency with previous versions of this report, the Trends database continues to use the production volumes for CAFE reporting. Both the General Label and Final GHG/CAFE data submissions contain a broad amount of data associated with CO_2 emissions and fuel economy, vehicle and engine technology, and vehicle performance metrics. The Trends database extracts only a portion of the data from the VERIFY database.

Through MY 2015, all Trends data is considered final since it is based on the Final GHG/CAFE compliance data. For MY 2016, all Trends data is preliminary since it is based on confidential pre-model year production projections. Final MY 2016 values will be published in next year's report. See Section 10.G below for a historical comparison of preliminary and final values.

While nearly the entire Trends database comes from formal automaker submissions, it also contains a small amount of data from external sources. For example, label fuel economy data for Sections 7 and 8 are from www.fueleconomy.gov. Also, we rely on published data from

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external sources for certain parameters of pre-MY 2011 vehicles, which are not universally available through automaker submissions: (1) engines with variable valve timing (VVT); (2) engines with cylinder deactivation; and (3) vehicle footprint, which is the product of wheelbase times average track width and upon which CO_2 emissions and CAFE standards are based. Beginning with MY 2011, automaker submissions have included data for VVT and cylinder deactivation. EPA projects footprint data for the preliminary MY 2016 fleet based on footprint values for existing models from previous years and footprint values for new vehicle designs available through public sources. Finally, vehicle 0-to-60 acceleration values are not provided by automakers, but are either calculated from other Trends data, as discussed in Section 3, or taken from external sources.

B. Harmonic Averaging of Fuel Economy Values

Averaging multiple fuel economy values must be done harmonically in order to obtain a correct mathematical result. Since fuel economy is expressed in miles per gallon (mpg), one critical assumption with any harmonic averaging of multiple fuel economy values is whether the distance term (miles, in the numerator of mpg) is fixed or variable. This report makes the assumption that the distance term in all mpg values is fixed, i.e., that for purposes of calculating a harmonically averaged fuel economy value, it is assumed that the distance term (representing miles travelled) is equivalent across various vehicle fuel economies. This assumption is the standard practice with harmonic averaging of multiple fuel economy values (including, for example, in calculations for CAFE standards compliance), and simplifies the calculations involved.

Mathematically, when assuming a fixed distance term as discussed above, harmonic averaging of multiple fuel economy values can be defined as the inverse of the average of the reciprocals of the individual fuel economy values. It is best illustrated by a simple example.

Consider a round trip of 600 miles. For the first 300-mile leg, the driver is alone with no other passengers or cargo, and, aided by a tailwind, uses 10 gallons of gasoline, for a fuel economy of 30 mpg. On the return 300-mile trip, with several passengers, some luggage, and a headwind, the driver uses 15 gallons of gasoline, for a fuel economy of 20 mpg. Many people will assume that the average fuel economy for the entire 600-mile trip is 25 mpg, the arithmetic (or simple) average of 30 mpg and 20 mpg. But, since the driver consumed 10 + 15 = 25 gallons of fuel during the trip, the actual fuel economy is 600 miles divided by 25 gallons, or 24 mpg.

Why is the actual 24 mpg less than the simple average of 25 mpg? Because the driver used more gallons while (s)he was getting 20 mpg than when (s)he was getting 30 mpg.

This same principle is often demonstrated in elementary school mathematics when an airplane makes a round trip, with a speed of 400 mph one way and 500 mph the other way. The average speed of 444 mph is less than 450 mph because the airplane spent more time going 400 mph than it did going 500 mph.

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As in both of the examples above, a harmonic average will typically yield a result that is slightly lower than the arithmetic average.

The following equation illustrates the use of harmonic averaging to obtain the correct mathematical result for the fuel economy example above:

$$\text{Average mpg} = \frac{2}{\left(\frac{1}{30} + \frac{1}{20}\right)} = 24 \text{ mpg}$$

The above example was for a single vehicle with two different fuel economies over two legs of a single round trip. But, the same mathematical principle holds for averaging the fuel economies of any number of vehicles. For example, the average fuel economy for a set of 10 vehicles, with three 30 mpg vehicles, four 25 mpg vehicles, and three 20 mpg vehicles would be (note that, in order to maintain the concept of averaging, the total number of vehicles in the numerator of the equation must equal the sum of the individual numerators in the denominator of the equation):

$$\text{Average mpg} = \frac{10}{\left(\frac{3}{30} + \frac{4}{25} + \frac{3}{20}\right)} = 24.4 \text{ mpg}$$

Note that arithmetic averaging, not harmonic averaging, provides the correct mathematical result for averaging fuel consumption values (in gallons per mile, the inverse of fuel economy) and CO_2 emissions (in grams per mile). In the first, round trip, example above, the first leg had a fuel consumption rate of 10 gallons over 300 miles, or 0.03333 gallons per mile. The second leg had a fuel consumption of 15 gallons over 300 miles, or 0.05 gallons per mile. Arithmetically averaging the two fuel consumption values, i.e., adding them up and dividing by two, yields 0.04167 gallons per mile, and the inverse of this is the correct fuel economy average of 24 mpg. Arithmetic averaging also works for CO_2 emissions values, i.e., the average of 200 g/mi and 400 g/mi is 300 g/mi CO_2 emissions.

In summary, fuel economy values must be harmonically averaged to maintain mathematical integrity, while fuel consumption values (in gallons per mile) and CO_2 emissions values (in grams per mile) can be arithmetically averaged.

C. Adjusted vs. Unadjusted, Laboratory Fuel Economy Values

Change in Emphasis from Unadjusted, Laboratory to Adjusted Data Beginning in 2001

Prior to 2001, EPA's Trends reports only included unadjusted, laboratory fuel economy values, which continue to be used as the basis for compliance with GHG/CAFE standards and passenger car fuel economy gas guzzler taxes. Beginning in 2001, Trends reports also included adjusted values which are EPA's best estimate of real world GHG emissions and fuel economy

performance. Now, most of the tables and figures in this report exclusively show adjusted fuel economy (and in some cases, adjusted CO_2 emissions) values.

One important distinction between the adjusted and the unadjusted, laboratory fuel economy values is that the methodology for determining the former has evolved over time to better reflect real world performance (see the next sub-section for more details). Some of the changes to the adjusted fuel economy value methodology are intended to account for changes in consumer driving behavior over time (e.g., higher speeds, higher acceleration rates, greater use of air conditioning). Since adjusted Trends values are intended to represent real world performance at any given time, modifications to the adjusted value methodology that reflect changes in consumer driving behavior have not been "propagated back" through the historical Trends database. We note that this is an exception to our general policy of "propagating back" changes throughout the historical Trends database, but in this case doing so would skew the historical fuel economy performance data (for example, by assuming that drivers in 1975 used air conditioning much more frequently, or traveled at higher speeds, than they did).

On the other hand, the methodology for determining unadjusted, laboratory fuel economy values has remained largely unchanged since this series began in the mid-1970s.[16] Unadjusted values therefore provide an excellent basis with which to compare long-term trends in vehicle design, apart from the factors that affect real world performance that are reflected in the adjusted values.

Table 10.1 shows both adjusted and unadjusted, laboratory fuel economy values, for the overall new car and truck fleet for MY 1975-2016, for city, highway, and combined city/highway. It also shows how the ratio of adjusted-to-unadjusted fuel economy has changed over time, reflecting that the methodology for adjusted fuel economy values has evolved, while the methodology for unadjusted fuel economy values has remain largely unchanged.

In addition to Table 10.1, the following tables also include unadjusted, laboratory fuel economy values: Tables 2.3, 2.4, 4.4, 9.1, 9.2, 10.2, and 10.4. Table 4.5 provides unadjusted, laboratory CO_2 emission values.

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[16] There were some relatively minor test procedure changes made in the late 1970s that, in the aggregate, made the city and highway tests slightly more demanding, i.e., the unadjusted fuel economy values for a given car after these test procedure changes were made are slightly lower relative to prior to the changes. EPA has long provided CAFE "test procedure adjustments" (TPAs) for passenger cars in recognition of the fact that the original CAFE standards were based on the EPA test procedures in place in 1975 (there are no TPAs for light trucks). The resulting impacts on the long-term unadjusted fuel economy trends are very small. As shown in Table 9.2, the TPAs for cars vary, and are typically in the range of 0.2-0.5 mpg for cars, or 0.1-0.3 mpg when the car TPAs are averaged over the combined car/truck fleet.

Table 10.1

Unadjusted, Laboratory and Adjusted Fuel Economy (MPG) for MY 1975–2016, Car and Truck

Model Year	Unadjusted City (MPG)	Unadjusted Highway (MPG)	Unadjusted Combined (55/45) (MPG)	Adjusted City (MPG)	Adjusted Highway (MPG)	Adjusted Combined (43/57) (MPG)	Ratio of Adjusted Combined to Unadjusted Combined
1975	13.4	18.7	15.3	12.0	14.6	13.1	85.2%
1976	14.6	20.2	16.7	13.2	15.7	14.2	85.1%
1977	15.6	21.3	17.7	14.0	16.6	15.1	85.1%
1978	16.3	22.5	18.6	14.7	17.5	15.8	85.1%
1979	16.5	22.3	18.7	14.9	17.4	15.9	85.1%
1980	19.6	27.5	22.5	17.6	21.5	19.2	85.2%
1981	20.9	29.5	24.1	18.8	23.0	20.5	85.2%
1982	21.3	30.7	24.7	19.2	23.9	21.1	85.2%
1983	21.2	30.6	24.6	19.0	23.9	21.0	85.3%
1984	21.2	30.8	24.6	19.1	24.0	21.0	85.3%
1985	21.5	31.3	25.0	19.3	24.4	21.3	85.3%
1986	22.1	32.2	25.7	19.8	25.0	21.8	85.0%
1987	22.2	32.6	25.9	19.8	25.3	22.0	84.7%
1988	22.1	32.7	25.9	19.6	25.2	21.9	84.4%
1989	21.7	32.3	25.4	19.1	24.8	21.4	84.2%
1990	21.4	32.2	25.2	18.7	24.6	21.2	83.9%
1991	21.6	32.5	25.4	18.8	24.7	21.3	83.6%
1992	21.0	32.1	24.9	18.2	24.4	20.8	83.4%
1993	21.2	32.4	25.1	18.2	24.4	20.9	83.1%
1994	20.8	31.6	24.6	17.8	23.8	20.4	82.9%
1995	20.8	32.1	24.7	17.7	24.1	20.5	82.7%
1996	20.8	32.2	24.8	17.6	24.0	20.4	82.4%
1997	20.6	31.8	24.5	17.4	23.6	20.2	82.2%
1998	20.6	31.9	24.5	17.2	23.6	20.1	81.9%
1999	20.3	31.2	24.1	16.9	23.0	19.7	81.7%
2000	20.5	31.4	24.3	16.9	23.0	19.8	81.3%
2001	20.5	31.1	24.2	16.8	22.8	19.6	81.0%
2002	20.4	30.9	24.1	16.6	22.5	19.5	80.7%
2003	20.6	31.3	24.3	16.7	22.7	19.6	80.4%
2004	20.2	31.0	24.0	16.3	22.4	19.3	80.2%
2005	21.0	32.1	24.8	16.8	23.1	19.9	79.8%
2006	21.2	32.6	25.2	17.0	23.4	20.1	79.8%
2007	21.8	33.4	25.8	17.4	24.0	20.6	79.6%
2008	22.1	34.0	26.3	17.7	24.4	21.0	79.5%
2009	23.8	36.4	28.2	18.9	26.0	22.4	79.1%
2010	24.1	36.6	28.4	19.1	26.2	22.6	79.0%
2011	23.7	36.5	28.1	18.8	26.1	22.4	79.3%
2012	25.2	38.7	29.9	19.9	27.6	23.7	78.9%
2013	25.9	39.7	30.7	20.5	28.3	24.3	78.7%
2014	25.9	39.6	30.7	20.5	28.2	24.3	78.7%
2015	26.6	40.5	31.4	21.0	28.8	24.8	78.5%
2016 (prelim)	27.5	41.8	32.5	21.6	29.7	25.6	78.2%

Methodological Approaches for Adjusted Fuel Economy Values

EPA has improved its methodology for estimating adjusted (or real world) fuel economy and CO_2 emissions performance over time. EPA's last methodological revisions for how we calculate city, highway, and combined fuel economy label estimates for cars and light-duty trucks were established in a December 2006 rulemaking (EPA 2006, 77872).

This current methodology incorporates equations that directly account for several important factors that affect fuel economy performance in the real world, such as high speeds, aggressive accelerations and decelerations, the use of air conditioning, and operation in cold temperatures, and indirectly account (through the use of a 9.5% universal downward adjustment factor) for a number of other factors that are not reflected in EPA laboratory test data such as changing fuel composition, wind, road conditions, etc. While some of these factors may not have changed (or may not have changed much) over time and therefore new estimation methods that account for these factors could be "propagated back" throughout the historical Trends database, we believe that many of the factors have changed significantly over time (e.g., highway speeds, acceleration rates, use of air conditioning), and therefore new estimation methods could not be fully "propagated back" through the historical Trends database without impacting the integrity of the historical database with respect to real world fuel economy performance.

There are two important consequences of this approach for users of this report. First, every adjusted fuel economy value in this report for 1986 and later model years is lower than shown in pre-2007 reports. Second, we employ unique approaches for generating adjusted fuel economy values in the historical Trends database for three distinct time frames. The following discussion will first address MY 1975-1985, then MY 2005-2016, and then, finally, the approach for the MY 1986-2004 time frame that represents a "phased-in" approach between the 1975-1985 and 2005-2016 time frames.

For the MY 1975-1985 time frame, the adjusted fuel economy values in the Trends database are calculated using the methodology adopted by EPA in an April 1984 rulemaking that established universal (i.e., same for all vehicles) fuel economy label adjustment factors of 0.9 for city fuel economy and 0.78 for highway fuel economy that took effect for MY 1985 vehicles (EPA 1984). Accordingly, for MY 1975-1985, adjusted city fuel economy is equal to 0.9 times the unadjusted, laboratory city fuel economy value, and adjusted highway fuel economy is 0.78 times the unadjusted, laboratory highway fuel economy. A single, combined adjusted fuel economy value is based on a 55% city/45% highway weighting factor. We believe that these adjustment factors are appropriate for new vehicles through the 1985 model year.

For the MY 2005-2016 time frame, the adjusted city and highway values in the Trends database for vehicles that undergo full "5-cycle" fuel economy testing (Federal Test Procedure for urban stop-and-go driving, Highway Fuel Economy Test for rural driving, US06 test for high speeds and aggressive driving, SC03 test for air conditioning operation, and cold FTP test for cold temperature operation) are calculated by weighting the 5-cycle test data according to

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the "composite" 5-cycle equations (EPA 2006, 77883-77886). The combined city/highway adjusted fuel economy values for these vehicles are based on a 43% city/57% highway weighting. In recent years, 10-15% of all vehicle fuel economy data were generated from the full 5-cycle test protocol.

It is important to emphasize that the 43% city/57% highway weighting used for adjusted 5-cycle fuel economy values beginning in MY 2005 is different from the 55% city/45% highway weighting used to generate adjusted fuel economy values for MY 1975-1985 in the Trends database. EPA's analysis of real world driving activity underlying the 5-cycle fuel economy methodology assumed a "speed cutpoint" of 45 miles per hour to differentiate between (and "bin" the amount of) city and highway driving (EPA 2006, 77904). Based on this speed cutpoint, the correct weighting for correlating the new city and highway fuel economy values with real world driving activity data from on-road vehicle studies, on a miles driven basis, is 43% city/57% highway, and therefore this weighting is necessary in order to maintain the integrity of projections of fleetwide fuel economy performance based on Trends data. The 55% city/45% highway weighting is still used for both Fuel Economy and Environment Labels and the CAFE and GHG emissions compliance programs, as well as the unadjusted, laboratory values provided in this report.

Most current vehicles do not undergo full 5-cycle testing; instead, manufacturers derive 5-cycle values from 2-cycle fuel economy test results (EPA Federal Test Procedure and Highway Fuel Economy Test) based on the relationship between 2-cycle and 5-cycle fuel economy data for the industry as a whole. Beginning with MY 2011, manufacturers were required to evaluate whether the fuel economy estimates for certification vehicles from 5-cycle tests are comparable to results from the less resource-intensive "derived 5-cycle" method. If the results are comparable, manufacturers can use the derived 5-cycle method for all vehicle models represented by the certification vehicle. If the full 5-cycle method yields significantly lower fuel economy estimates than the derived 5-cycle method, then the manufacturer must use the full 5-cycle method for all models represented by the certification vehicle.

For vehicles that can use the derived 5-cycle method, the following equations are used to convert unadjusted, laboratory fuel economy values for city and highway to adjusted fuel economy values.

$$\text{ADJ CITY} = \frac{1}{\left(0.003259 + \frac{1.1805}{\text{LAB CITY}}\right)}$$

$$\text{ADJ HWY} = \frac{1}{\left(0.001376 + \frac{1.3466}{\text{LAB HWY}}\right)}$$

As above, these values are weighted 43% city/57% highway in order to calculate a single, adjusted combined fuel economy value.[17] For more details on the specific equations that allow an automaker to calculate new label values using either the vehicle-specific 5-cycle test data or the derived 5-cycle approach, and the impact of these changes on average fuel economy label values, see the preamble to the 2006 regulations (EPA 2006).

How much different, on average, are the fuel economy values based on the derived 5-cycle method from the values based on the universal adjustment factors for MY 1975-1985? These derived 5-cycle method values are lower than values based on the universal adjustment factors for MY 1975-1985, and the differences are greater for higher fuel economy vehicles than for lower fuel economy vehicles. For example, compared to the use of the universal adjustment factors for MY 1975-1985, a 15 mpg city value will be reduced by an additional 10%, while a 50 mpg city value will be reduced by an additional 18%. Likewise, a 20 mpg highway value will be reduced by an additional 7%, while a 50 mpg highway value will be reduced by an additional 11%. In the 2006 rulemaking, EPA projected an overall average fleetwide adjustment of 11% lower for city fuel economy and 8% lower for highway fuel economy, beyond that in the older label adjustment methodology. The appropriate fleetwide factors to convert adjusted MY 1975-1985 fuel economy values to the adjusted derived 5-cycle, 43% city/57% highway weighting, fuel economy values are dependent on the city fuel economy-to-highway fuel economy ratios in the fleet. On average, for the current fleet, combining the 11% lower adjustment for city fuel economy, the 8% lower adjustment for highway fuel economy, and the shift to the 43% city/57% highway weighting, the combined city/highway fuel economy values are about 8 % lower than those based on the older label adjustment methodology. This 8% lower value is the average impact for a fleet with the mpg and city fuel economy-to-highway fuel economy characteristics of the current fleet, and would not be the appropriate value for individual models, partial fleet segments, or for past or future fleets with different mpg and city fuel economy-to-highway fuel economy distributions.

Finally, manufacturers have the option of voluntarily using lower fuel economy label estimates than those resulting from the full 5-cycle or derived 5-cycle approaches discussed above. In the rare cases where automakers choose to do so, we base adjusted values on these voluntary lower city and highway fuel economy labels, using the 43% city/57% highway weighting.

For the MY 1986-2004 time frame, we calculate adjusted fuel economy values based on the simplifying assumption that the impacts of the factors that have led to lower real world fuel economy, as outlined in the 2006 rulemaking and discussed above, occurred in a gradual (i.e., linear) manner over the 20 years from 1986 through 2005. We did not attempt to perform a year-by-year analysis to determine the extent to which the many relevant factors (including higher highway speed limits, more aggressive driving, increasing vehicle horsepower-to-weight

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[17] Note that EPA has issued fuel economy labeling guidance updating the derived 5-cycle coefficients for MY 2017 vehicles. See iaspub.epa.gov/otaqpub/display_file.jsp?docid=35113&flag=1. Although this report continues to use the original, derived 5-cycle equations shown above, EPA intends to update future Trends reports to reflect the new, derived 5-cycle equations shown in the labeling guidance document.

ratios, suburbanization, congestion, greater use of air conditioning, gasoline composition, et al.) that have affected real world fuel economy since 1985 have changed over time. We simply assumed 5% (1/20) of the fully phased-in downward adjustment for city and highway values would be reflected in the 1986 data, 10% of this adjustment would be reflected in the 1987 data, etc., up to 95% of this adjustment in 2004 and the full 100% adjustment in 2005 and later years. Likewise, EPA has assumed the 55% city/45% highway weighting changes to a 43% city/57% highway weighting in a linear fashion over the 1986 to 2005 time period as well.

One consequence of the approach used in this report is that there are, in effect, 21 different sets of numerical adjustments for determining adjusted fuel economy values: a constant numerical adjustment for MY 1975-1985, unique numerical adjustments for each of the 19 model years from 1986 through 2004, and a constant numerical adjustment for MY 2005-2016. Due in part to this, the ratio of the adjusted-to-unadjusted fuel economy values have been changing over time. As shown in Table 10.1, the adjusted-to-unadjusted fuel economy ratio was around 85% for MY 1975-1985 data, decreased during the MY 1986-2004 phase-in period to about 80% in MY 2004, and has since declined more slowly to a preliminary value of 78.2% in MY 2016. This slight decline since MY 2005 has occurred even though the basic methodology for determining adjusted fuel economy values has been fixed since MY 2005, and it is possible that the adjusted-to-unadjusted fuel economy ratio will continue to change in the future. Any changes in this ratio would be due to the fact that the current adjusted fuel economy methodology now incorporates tests unique to the adjusted methodology and is no longer strictly calculated from the laboratory fuel economy results. On the one hand, all other things being equal, use of the derived 5-cycle equations would be expected to lower this ratio over time since, as discussed earlier, the equations apply a greater percentage reduction to high fuel economy values than to low fuel economy values. On the other hand, it is also possible that vehicle powertrain designs may be more robust in the future with respect to a broader set of in-use driving conditions, and given that the 5-cycle methodology is data driven, it is impossible to predict the direction of changes in the adjusted-to-unadjusted fuel economy ratio in the future. This report will continue to monitor this data-driven adjusted-to-unadjusted fuel economy ratio.

One Illustrative Example of Multiple Fuel Economy Metrics and Values

One potentially confusing element of any discussion of historical fuel economy values is the various metrics by which fuel economy can be expressed. As an illustration to help the reader understand the various fuel economy values that can be associated with an individual vehicle, Table 10.2 shows four different ways to express the fuel economy of the MY 2005 Honda Insight.

Unadjusted, laboratory city and highway fuel economy values are direct fuel economy measurements from the formal EPA 2-cycle city (Federal Test Procedure, or urban commute) and highway laboratory tests. They are harmonically averaged, and weighted 55% city/45% highway, to generate a combined value. These values form the basis for automaker compliance

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with CAFE standards. The 2005 Honda Insight had an unadjusted city value of 68 mpg, an unadjusted highway value of 84 mpg, and an unadjusted combined value of 74 mpg.

At the time, the MY 2005 Honda Insight had an original city label value of 61 mpg, which was calculated by multiplying its unadjusted city test value of 68 mpg by 0.9. Likewise, its original highway value was 66 mpg, calculated by multiplying its unadjusted highway test value of 84 mpg by 0.78. Harmonically averaging these values, with a 55% city/45% highway weighting, led to a combined original MY 2005 label value of 63 mpg.

Today, as a used car, the 2005 Honda Insight would have lower label values based on the derived 5-cycle method (reflecting, in addition to 2-cycle urban commuting and rural highway operation, additional conditions such as high speed/high acceleration, high temperature/air conditioning, and cold temperature operation) for determining city and highway values, first implemented in MY 2008, and discussed in the previous sub-section. For the 2005 Insight, the derived 5-cycle method yields a city label value of 48 mpg and a highway value of 58 mpg. Today's labels continue to use a 55% city/45% highway weighting, and the harmonically averaged, 55% city/45% highway weighted, combined value for the 2005 Insight is 52 mpg. These current label values, based on the 5-cycle methodology, are considerably lower than the original label values.

Finally, for the MY 2005 Honda Insight, this Trends report uses the adjusted fuel economy methodology discussed in the previous sub-section, that is used in the Trends report for all vehicles beginning in MY 2005. The adjusted Trends city and highway values are the same as those for the current label, since both the current label and the adjusted Trends approach use the same derived 5-cycle methodology. But, the adjusted Trends approach uses a weighting of 43% city/57% highway to best correlate with the driving activity studies underlying the 5-cycle methodology. This different city/highway weighting leads to a 53 mpg combined value, slightly higher than the 52 mpg combined value for the current label. This 53 mpg combined adjusted value is 16% lower than the 63 mpg combined value that was the official label value for the MY 2005 Insight. As discussed in the previous subsection, the impact of the 5-cycle methodology is greater for high-mpg vehicles than for low-mpg vehicles.

Table 10.2
Four Different Fuel Economy Metrics for the MY 2005 Honda Insight

Fuel Economy Metric	Fuel Economy Value (MPG)			Basis	City/Highway Weighting
	Comb	City	Hwy		
Unadjusted, Laboratory	74	68	84	Unadjusted 2-cycle city and highway test values	55%/45%
Original MY 2005 Label	63	61	66	City test x 0.9 Highway test x 0.78	55%/45%
Current Label Methodology	52	48	58	Adjusted 5-cycle methodology	55%/45%
Current Adjusted Trends	53	48	58	Adjusted 5-cycle methodology	43%/57%

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PHEV Fuel Economy Calculations

As described in Section 7, PHEV fuel economy values take into consideration the percentage of miles that are projected to be driven in charge depleting versus charge sustaining modes of operation by using a utility factor to calculate city and highway mpge values, which can then be used to produce combined mpge values. However, the utility factors that are used for fleetwide calculations are somewhat different than those that are used to create label values for individual vehicles. For label values in Sections 7 and 8, multi-day individual utility factors (MDIUF) are used to incorporate "a driver's day to day variation into the utility calculation." (SAE J2841, page 3). For Trends fleetwide calculations, fleet utility factors (FUF) are applied to "calculate the expected fuel and electric consumption of an entire fleet of vehicles." (SAE J2841, page 2). Because Trends weights adjusted city and highway values using a 43% city/57% highway weighting, FUFs created for a 43/57 ratio are used for the adjusted mpge values in this report.

D. VEHICLE TAILPIPE CO_2 EMISSIONS DATA

CO_2 emissions data were added to the entire historical Trends database beginning with the 2009 report. CO_2 emissions values in this report are generally calculated from corresponding fuel economy values using the fuel-specific CO_2 emissions per gallon factors described below. Accordingly, the adjusted and unadjusted, laboratory CO_2 emissions values in this report reflect the methodological approaches underlying the adjusted and unadjusted, laboratory fuel economy values that were discussed in detail in the previous section.

While CO_2 emissions data is included in several key summary tables and figures in the report, there are many other tables and figures that present fuel economy values but not CO_2 emissions values. This section provides a simple method that a reader can use to estimate CO_2 emissions values from any fuel economy value in the report.

If a fuel economy value is given for a single gasoline vehicle, or a 100% gasoline vehicle fleet, one can calculate the corresponding CO_2 emissions value by simply dividing 8887 (which is a typical value for the grams of CO_2 per gallon of gasoline test fuel, assuming all the carbon is converted to CO_2) by the fuel economy value in miles per gallon. For example, 8887 divided by a gasoline vehicle fuel economy of 30 mpg would yield an equivalent CO_2 emissions value of 296 grams per mile. This is the methodology used to generate the CO_2 emissions values for all of the gasoline vehicles in the Trends database.

Since gasoline vehicle production has accounted for 99+% of all light-duty vehicle production for most of the model years since 1975, this simple approach yields accurate results for most model years.

Diesel fuel has 14.5% higher carbon content per gallon than gasoline. To calculate a CO_2 equivalent value for a diesel vehicle, one should divide 10,180 by the diesel vehicle fuel economy value. Accordingly, a 30 mpg diesel vehicle would have a CO_2 equivalent value of

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339 grams per mile. This is the methodology used to generate the CO_2 emissions values for the relatively small number of diesel vehicles in the Trends database.

For electric vehicles, the tailpipe CO_2 emissions are 0 grams per mile (see Section 7 for a discussion of upstream emissions). For CNG vehicles, we recommend using an emission factor of 7030 grams per gallon of gasoline equivalent to approximate CO_2 emissions. For PHEVs, the process of calculating CO_2 grams per mile is more complex, and this report uses a parallel methodology described in Section 10.C for PHEV fuel economy values, calculating the carbon-related exhaust emissions from test data and then converting the carbon content to CO_2.

To make the most accurate conversions of industry-wide fuel economy values to CO_2 emissions values, readers should divide model year-specific industry-wide values for grams of CO_2 per gallon in Table 10.3 by industry-wide fuel economy values in miles per gallon. Two sets of model year-specific industry wide CO_2 per gallon values are provided, with the final column providing a value representing that model year fleet including alternative fuel vehicles, and the next-to-last column providing a value representing that model year fleet excluding alternative fuel vehicles (i.e., just gasoline and diesel vehicles).

Readers must make judgment calls about how to best convert fuel economy values that do not represent industry-wide values (e.g., just cars or vehicles with 5-speed automatic transmissions). Options include the two model year-specific CO_2 emissions per gallon weightings in Table 10.3 (with and without alternative fuel vehicles) or the gasoline value of 8887 (implicitly assuming no diesels or alternative fuel vehicles in that database component). Or a user can generate a customized grams of CO_2 emissions per gallon value based on the make-up of the vehicles in question.

Finally, it is important to note that the unadjusted, laboratory tailpipe CO_2 emissions values included in a few tables in this report are very similar to, but not exactly equal to, the 2-cycle tailpipe CO_2 emissions values provided in the annual EPA GHG Manufacturer Performance Report www.epa.gov/regulations-emissions-vehicles-and-engines/ghg-emission-standards-light-duty-vehicles-manufacturer. The two most important reasons for slight differences in car and truck CO_2 emissions data is 1) the values in this Trends report are calculated from generic fuel-specific emissions factors discussed above, while the values in the GHG Performance report use formal compliance data based on actual carbon content of the test fuel used at the time of the compliance test, and 2) some manufacturers may choose to use an optional compliance approach which adds nitrous oxide and methane emissions to their CO_2 (more accurately CREE, see next section) values while the Trends data does not reflect nitrous oxide and methane emissions for any automakers. In addition, there is another factor that can lead to differences in combined car-truck values only: Trends report data are not weighted for any differences in lifetime vehicle miles traveled (VMT) between cars and trucks, while the GHG Performance report assumes slightly higher lifetime VMT for trucks than cars as required by compliance regulations. In general, when there are slight differences between the Trends unadjusted CO_2 data and GHG Performance 2-cycle CO_2 data, the latter are typically slightly higher than the former.

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Table 10.3
Factors for Converting Industry-Wide Fuel Economy Values from this Report to Carbon Dioxide Emissions Values

Model Year	Gasoline Production Share	Diesel Production Share	AFV Production Share	Weighted CO_2 per Gallon (grams) Without AFVs	Weighted CO_2 per Gallon (grams) With AFVs
1975	99.8%	0.2%	-	8888	8888
1976	99.8%	0.2%	-	8889	8889
1977	99.6%	0.4%	-	8890	8890
1978	99.1%	0.9%	-	8895	8895
1979	98.0%	2.0%	-	8906	8906
1980	95.7%	4.3%	-	8930	8930
1981	94.1%	5.9%	-	8948	8948
1982	94.4%	5.6%	-	8948	8948
1983	97.3%	2.7%	-	8916	8916
1984	98.2%	1.8%	-	8905	8905
1985	99.1%	0.9%	-	8897	8897
1986	99.6%	0.4%	-	8891	8891
1987	99.7%	0.3%	-	8890	8890
1988	99.9%	0.1%	-	8888	8888
1989	99.9%	0.1%	-	8888	8888
1990	99.9%	0.1%	-	8888	8888
1991	99.9%	0.1%	-	8888	8888
1992	99.9%	0.1%	-	8888	8888
1993	100.0%	-	-	8887	8887
1994	100.0%	0.0%	-	8887	8887
1995	100.0%	0.0%	-	8887	8887
1996	99.9%	0.1%	-	8888	8888
1997	99.9%	0.1%	-	8888	8888
1998	99.9%	0.1%	-	8888	8888
1999	99.9%	0.1%	-	8888	8888
2000	99.9%	0.1%	-	8888	8888
2001	99.9%	0.1%	-	8888	8888
2002	99.8%	0.2%	-	8888	8888
2003	99.8%	0.2%	-	8888	8888
2004	99.9%	0.1%	-	8888	8888
2005	99.7%	0.3%	-	8889	8889
2006	99.6%	0.4%	-	8890	8890
2007	99.9%	0.1%	-	8888	8888
2008	99.9%	0.1%	-	8889	8889
2009	99.5%	0.5%	-	8892	8892
2010	99.3%	0.7%	0.00%	8893	8893
2011	99.1%	0.8%	0.10%	8895	8892
2012	98.7%	0.9%	0.40%	8896	8890
2013	98.4%	0.9%	0.70%	8894	8885
2014	98.3%	1.0%	0.70%	8897	8885
2015	98.3%	0.9%	0.70%	8894	8880
2016 (prelim)	*97.6%*	*0.7%*	*1.70%*	*8897*	*8863*

E. Vehicle-Related GHG Emissions Sources Other Than Tailpipe CO_2 Emissions

The CO_2 emissions data in this report reflect the sum of the vehicle tailpipe emissions of CO_2, carbon monoxide, and hydrocarbons, with the latter two converted to equivalent CO_2 levels on a mass basis. While carbon monoxide and hydrocarbon emissions add, on average, less than one percent to overall CO_2 tailpipe emissions values, these compounds are included in the tailpipe CO_2 emissions data because they are converted to CO_2 relatively quickly in the atmosphere, and to maintain consistency with greenhouse gas (GHG) emissions standards compliance. EPA regulations refer to this sum as "carbon related exhaust emissions" or CREE, but we use the term CO_2 emissions in this report for simplicity.

It is important to emphasize that tailpipe CO_2 or CREE emissions do not represent the entire GHG burden associated with a personal vehicle, and there are at least six other vehicle-related GHG sources. While this report cannot provide authoritative data for each of these other vehicle-related GHG sources, they will be briefly identified and discussed below for context, with an emphasis on the approximate magnitude of each source relative to the magnitude of the tailpipe CO_2 emissions that are documented in this report.

Tailpipe emissions of nitrous oxide (N2O)

Nitrous oxide is a greenhouse gas and a constituent in the exhaust from internal combustion engines. It is emitted from gasoline and diesel vehicles during specific catalytic converter temperature conditions conducive to its formation. EPA does not currently require N_2O emissions measurement as a part of the formal EPA vehicle certification process (it will begin to be required in the MY 2017-2019 timeframe), so we only have limited test data at this time. Based on this limited data, EPA estimates typical N_2O emissions from late model gasoline cars to be on the order of 0.005 g/mi (EPA and DOT 2010, 25422). With a global warming potential of 298, this yields a CO_2-equivalent value of approximately 1.5 g/mi or about 0.4% of the 358 g/mi adjusted fleetwide CO_2 emissions value for MY 2015. Under the National Program regulations for MY 2012-2025, EPA has established an N_2O per-vehicle emissions cap of 0.010 g/mi, which is not intended to reduce N_2O emissions, but rather to ensure that there are no increases in the future (EPA and DOT 2010, 25421).

Tailpipe emissions of methane (CH_4)

Methane is a greenhouse gas and also a constituent in internal combustion engine exhaust. As the simplest hydrocarbon compound (one carbon atom and four hydrogen atoms), it is one of the large number of hydrocarbon compounds formed during the imperfect combustion of hydrocarbon-based fuels such as gasoline and diesel (and the most prominent hydrocarbon compound in compressed natural gas vehicle exhaust). EPA requires that CH_4 emissions be measured during the formal EPA vehicle certification program. Typical methane emissions from late model gasoline cars are about 0.015 g/mi (EPA and DOT 2010, 25423). With a

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global warming potential of 25, this yields a CO_2-equivalent value of approximately 0.4 g/mi, or about 0.1% of the 358 g/mi adjusted fleetwide CO_2 emissions value for MY 2015. Under the National Program regulations for MY 2012-2025, EPA has established a CH_4 per-vehicle emissions cap of 0.03 g/mi, which is not intended to reduce CH_4 emissions, but rather to ensure that there are no increases in the future (EPA and DOT 2010, 25421 and EPA and DOT 2012, 62770).

Vehicle GHG emissions associated with air conditioner refrigerants

Nearly all new personal vehicles in the U.S. are equipped with air conditioners. Until relatively recently, all automotive air conditioners used the refrigerant HFC-134a, which is a very strong greenhouse gas with a global warming potency of 1,430. Small amounts of refrigerant leakage can occur during routine operation, during maintenance and servicing, and during ultimate disposal. Based on the combination of relatively small mass leakage with the extremely high global warming potency, EPA estimates typical HFC-134a CO_2-equivalent values of 13.8 g/mi for cars and 17.2 g/mi for light trucks, or about 4% of the 358 g/mi adjusted fleetwide CO_2 emissions value for MY 2015 (EPA and DOT 2012, 62805). There are no standards under the MY 2012-2025 National Program for the control of air conditioner refrigerant leakage emissions, but automakers can earn credits for reducing leakage emissions that can be used to help achieve compliance with the tailpipe CO_2 emissions standards. The GHG Manufacturer Performance Report for MY 2015 showed that automakers generated, on average, about 6 g/mi CO_2-equivalent credit due to reduced air conditioner refrigerant leakage in MY 2015 (EPA 2016). Some automakers are beginning to use a new air conditioner refrigerant, HFO-1234yf, which has a much lower global warming potency of 4.

GHG emissions associated with fuel production and distribution

Motor vehicle fuel production and distribution (often referred to as "upstream" emissions) can produce significant GHG emissions. The relative relationship between vehicle tailpipe CO_2 emissions and vehicle fuel-related production/distribution GHG emissions can vary greatly. For example, for typical gasoline today, a rule-of-thumb is that gasoline production/distribution (all steps including oil production, oil transport, refining, and gasoline transport to the service station) yields about 25% of the GHG emissions associated with vehicle tailpipe CO_2 emissions. Based on this rule-of-thumb, gasoline production/distribution-related GHG emissions associated with the 358 g/mi adjusted fleetwide CO_2 vehicle tailpipe emissions value for MY 2015 would be about 90 g/mi, for a total adjusted fleetwide MY 2015 CO_2 tailpipe plus gasoline production/distribution GHG emissions value of about 448 g/mi. Other fuels currently used in personal vehicles, such as diesel from crude oil, ethanol from corn, and compressed natural gas, can also have significant fuel production/distribution GHG emissions. However, like gasoline, these GHG emissions are typically much smaller than those from the vehicle tailpipe.

Some fuels have very different vehicle tailpipe vs fuel production/distribution characteristics. For example, electric vehicles have zero tailpipe emissions, and so all GHG emissions

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associated with electric vehicle operation are associated with the generation and distribution of electricity. The same goes for hydrogen. On the other hand, carbon-based fuels produced from renewable feedstocks could have similar vehicle tailpipe emissions (note there is an accounting issue here, while Trends would assign tailpipe emissions to the vehicle, current IPCC rules do not count tailpipe emissions for renewable fuels), but "negative" fuel production/distribution-related GHG emissions if little or no fossil fuels are used in the production/distribution of the fuel and the "carbon uptake" associated with renewable fuels is accounted for at the production/distribution step.

There is an exhaustive literature on the relative vehicle versus fuel-related GHG emissions for various fuel/feedstock combinations, and the reader should consult the literature for detailed analyses.

GHG emissions associated with vehicle manufacturing and assembly

Some studies estimate that the GHG emissions associated with vehicle and component manufacturing and assembly for conventional gasoline vehicles are on the order of 10-15% of total life-cycle vehicle GHG emissions (where vehicle tailpipe and fuel production/distribution accounts for nearly all of the remaining vehicle life cycle emissions).[18] Based on the approximate 448 g/mi adjusted fleetwide value calculated above for MY 2015 CO_2 tailpipe plus gasoline production/distribution GHG emissions, this would imply that typical vehicle and component manufacturing and assembly GHG emissions would be on the order of approximately 45-70 g/mi.

GHG emissions associated with vehicle disposal

The GHG emissions associated with vehicle disposal, or end-of-life, are typically not more than a few percent of total life-cycle vehicle emissions for a conventional gasoline vehicle. Based on the above approximations, this would imply that GHG emissions associated with vehicle disposal might be on the order of 10 g/mi or less.

F. OTHER DATABASE METHODOLOGY ISSUES

Air Conditioner Efficiency and Off-Cycle Credits

Under the EPA greenhouse gas emissions standards for MY 2012-2025, manufacturers have the option of earning air conditioner efficiency and off-cycle CO_2 emissions credits for the utilization of technologies that yield real world CO_2 emissions reductions, but which are not reflected on the 2-cycle compliance tests. It is expected that most, and maybe all, of the

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[18] For example, see Samaras, C. and Meisterling, K. Life Cycle Assessment of Greenhouse Gas Emissions from Plug-in Hybrid Vehicles: Implications for Policy. *Environmental Science & Technology* 2008, 42 (9):3170–3176, or Notter, D. et al. Contribution of Li-Ion Batteries to the Environmental Impact of Electric Vehicles. *Environmental Science & Technology* 2010, 44 (17): 6550-6556.

technologies that earn air conditioner efficiency and off-cycle CO_2 emissions credits will also reduce real world fuel consumption.[19]

The adjusted CO_2 tailpipe emissions and fuel economy values in this report reflect air conditioner efficiency improvements for the fraction of vehicles that undergo full 5-cycle testing as that testing includes a cycle with maximum air conditioning operation at 95 degrees Fahrenheit (see Section 10.C). At this time, the adjusted values do not reflect air conditioner efficiency improvements for those vehicles that do not undergo full 5-cycle testing and which utilize the derived 5-cycle equations. In addition, the adjusted values likely do not reflect certain off-cycle credit technologies. This is primarily due to the fact that, at this time, some manufacturers submit credits data only on a fleetwide basis, rather than on a model by model basis which would be necessary to fully integrate credits data with the full Trends database.

MY 2015 credits data provided in the EPA GHG Manufacturer Performance Report, available at www.epa.gov/regulations-emissions-vehicles-and-engines/ghg-emission-standards-light-duty-vehicles-manufacturer, show that total air conditioner efficiency credits (some of which are reflected in adjusted values as discussed above) were 2 g/mi and off-cycle credits were 3 g/mi. Accordingly, at most these credits could reduce adjusted MY 2015 CO_2 tailpipe emission values by about 5 g/mi, which would translate to an adjusted fuel economy increase of approximately 0.3 mpg. The same report also shows that total air conditioner efficiency and off-cycle credits were unchanged from MY 2014 to MY 2015. Again, most of these credits are not reflected in the Trends database.

EPA will continue to consider the question of whether, and if so how, to account for air conditioner efficiency and off-cycle CO_2 emissions credits in future reports.

Changes in Car-Truck Classification Definitions

Car-truck definitions through the 2010 report were based EPA's engineering judgment. Until recently, EPA and NHTSA had slightly different regulatory definitions for car-truck classifications with respect to health-related emissions and fuel economy, respectively, and the Trends report followed a third approach, though in practice there was broad (though not universal) agreement among the three approaches.

Beginning with the 2011 report, Trends car-truck classifications followed current regulatory definitions used by both EPA and NHTSA for CO_2 emissions and fuel economy standards. See definitions for passenger automobiles (cars) and non-passenger automobiles (trucks) later in this section. These current definitions differ from those used in older versions of this report, and reflect a decision by NHTSA to reclassify many small, 2-wheel drive, sport utility vehicles (SUVs) from the truck category to the car category, beginning with MY 2011. When

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[19] Air conditioner efficiency and off-cycle credits are the two types of credits that could impact the adjusted CO_2 tailpipe emissions and fuel economy values provided in this report. Other regulatory credits (e.g., for dual fuel vehicles or for air conditioner refrigerant leakage) and incentives (e.g., for advanced technologies) would not impact adjusted CO_2 tailpipe emissions or fuel economy values.

this re-classification was initiated in the 2011 report, the absolute truck share decreased by approximately 10%.

The current car-truck definitions have been "propagated back" throughout the entire historical Trends database to maintain the integrity of long-term trends of car and truck production share. Since we did not have all of the requisite technical information on which to make retroactive car-truck classifications, we used engineering judgment to classify past models.

Inclusion of Medium-Duty Passenger Vehicles

Beginning with the 2011 report, medium-duty passenger vehicles (MDPVs), those SUVs and passenger vans (but, not pickup trucks) with gross vehicle weight ratings between 8500 and 10,000 pounds, are included in the light-duty truck category. This coincided with new regulations by NHTSA to treat these vehicles as light-duty, rather than heavy-duty, vehicles beginning in MY 2011. This represents a minor change to the database, since the number of MDPVs is much smaller than it once was (e.g., only 6500 MDPVs were sold in MY 2012). It should be noted that this is one change to the database that has not been "propagated back" through the historic database, as we do not have MDPV data prior to MY 2011. Accordingly, this represents a small inflection point for the database for the overall car and truck fleet in MY 2011; the inclusion of MDPVs decreased average adjusted fuel economy by 0.01 mpg and increased average adjusted CO_2 emissions by 0.3 g/mi, compared to the fleet without MDPVs. The impacts on the truck fleet only were about twice as high, but still very small in absolute terms.

G. COMPARISON OF PRELIMINARY AND FINAL FLEETWIDE FUEL ECONOMY VALUES

In recent years, the data for the last model year included in each report has been preliminary (i.e., based on projected vehicle production volumes provided by automakers prior to the beginning of the model year), while the data for all other model years has been final. This leads to the logical question, how accurate have the preliminary projections been?

Table 10.4 compares the preliminary and final fleetwide fuel economy values for recent years (note that the differences for CO_2 emissions data would be similar, on a percentage basis).

For the adjusted fuel economy data, values are only shown beginning in MY 2007, as final adjusted values in this report reflect the revised methodology for calculating adjusted fuel economy values beginning with the 2007 report and therefore the comparable preliminary values prior to MY 2007 would not reflect an apples-to-apples comparison.

It is important to note that there isn't a perfect apples-to-apples comparison for MY 2011-2014, due to a number of small data issues, such as alternative fuel vehicle data. The preliminary values in Table 10.4 through MY 2014 did not integrate AFV data. The final

values in Table 10.4 are the values reported elsewhere in this report and do include alternative fuel vehicle data. The differences due to this will be small, on the order of 0.1 mpg or less.

Table 10.4 shows that, since MY 2007, the final adjusted fuel economy values have generally been pretty close to the preliminary adjusted fuel economy values. The major exceptions have been MY 2009, when the final value was 1.3 mpg higher, and MY 2011, when the final value was 0.4 mpg lower.

Comparative unadjusted fuel economy data are shown back to MY 2000. Again, the final values have been fairly close to the preliminary values, and the biggest outlier was MY 2009, when the final unadjusted value was 1.8 mpg higher than the preliminary value. There was considerable market turmoil in MY 2009 driven by the economic recession.

Table 10.4

Comparison of Preliminary and Final Fuel Economy Values, Both Car and Truck

Model Year	Adjusted Fuel Economy (MPG)			Unadjusted Fuel Economy (MPG)		
	Preliminary Value	Final Value	Final Minus Preliminary	Preliminary Value	Final Value	Final Minus Preliminary
2000	-	-	-	24.0	24.3	+0.3
2001	-	-	-	23.9	24.2	+0.3
2002	-	-	-	24.0	24.1	+0.1
2003	-	-	-	24.4	24.3	-0.1
2004	-	-	-	24.4	24.0	-0.4
2005	-	-	-	24.6	24.8	+0.2
2006	-	-	-	24.6	25.2	+0.6
2007	20.2	20.6	+0.4	25.3	25.8	+0.5
2008	20.8	21.0	+0.2	26.0	26.3	+0.3
2009	21.1	22.4	+1.3	26.4	28.2	+1.8
2010	22.5	22.6	+0.1	28.3	28.4	+0.1
2011	22.8	22.4	-0.4	28.6	28.1	-0.5
2012	23.8	23.7	-0.1	30.0	29.8	-0.2
2013	24.0	24.3	+0.3	30.3	30.7	+0.4
2014	24.2	24.3	+0.1	30.6	30.7	+0.1
2015	24.7	24.8	+0.1	31.2	31.4	+0.2
2016 (prelim)	25.6	-	-	32.5	-	-

H. Definitions and Acronyms

Electric vehicle (EV) means a motor vehicle that is powered solely by an electric motor drawing current from a rechargeable energy storage system, such as from storage batteries or other portable electrical energy storage devices. For the Trends report, electric vehicles do not generally include fuel cell vehicles.

Flexible fuel vehicle (FFV) means any motor vehicle engineered and designed to be operated on a petroleum fuel and on a methanol or ethanol fuel, or any mixture of the petroleum fuel and methanol or ethanol. Methanol-fueled and ethanol-fueled vehicles that are only marginally functional when using gasoline (e.g., the engine has a drop in rated horsepower of more than 80 percent) are not flexible fuel vehicles.

Footprint means the product of average track width (rounded to the nearest tenth of an inch) and wheelbase (measured in inches and rounded to the nearest tenth of an inch), divided by 144 and then rounded to the nearest tenth of a square foot, where the average track width is the average of the front and rear track widths, where each is measured in inches and rounded to the nearest tenth of an inch.

Fuel cell vehicle (FCV) means an electric vehicle propelled solely by an electric motor where energy for the motor is supplied by an electrochemical cell that produces electricity via the non-combustion reaction of a consumable fuel, typically hydrogen.

Gasoline gallon equivalent means an amount of electricity or fuel with the energy equivalence of one gallon of gasoline. For purposes of the Trends report, one gallon of gasoline is equivalent to 33.705 kilowatt-hours of electricity or 121.5 standard cubic feet of natural gas.

Hybrid electric vehicle (HEV) means a motor vehicle which draws propulsion energy from onboard sources of stored energy that are both an internal combustion engine or heat engine using consumable fuel, and a rechargeable energy storage system such as a battery, capacitor, hydraulic accumulator, or flywheel, where recharge energy for the energy storage system comes solely from sources on board the vehicle.

Light Truck means an automobile that is not a car or a work truck and includes vehicles described in paragraphs (a) and (b) below:

> (a) An automobile designed to perform at least one of the following functions:
> (1) Transport more than 10 persons;
> (2) Provide temporary living quarters;
> (3) Transport property on an open bed;
> (4) Provide, as sold to the first retail purchaser, greater cargo-carrying than passenger-carrying volume, such as in a cargo van; if a vehicle is sold with a second-row seat, its cargo-carrying volume is determined with that seat installed, regardless of whether the manufacturer has described that seat as optional; or
> (5) Permit expanded use of the automobile for cargo-carrying purposes or other nonpassenger-carrying purposes through:

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(i) For non-passenger automobiles manufactured in model year 2008 and beyond, for vehicles equipped with at least 3 rows of designated seating positions as standard equipment, permit expanded use of the automobile for cargo-carrying purposes or other nonpassenger-carrying purposes through the removal or stowing of foldable or pivoting seats so as to create a flat, leveled cargo surface extending from the forwardmost point of installation of those seats to the rear of the automobile's interior.

(b) An automobile capable of off-highway operation, as indicated by the fact that it:
(1) (i) Has 4-wheel drive; or
(ii) Is rated at more than 6000 pounds gross vehicle weight; and
(2) Has at least four of the following characteristics calculated when the automobile is at curb weight, on a level surface, with the front wheels parallel to the automobile's longitudinal centerline, and the tires inflated to the manufacturer's recommended pressure—
(i) Approach angle of not less than 28 degrees.
(ii) Breakover angle of not less than 14 degrees.
(iii) Departure angle of not less than 20 degrees.
(iv) Running clearance of not less than 20 centimeters.
(v) Front and rear axle clearances of not less than 18 centimeters each.
Please see Section 10.F for Changes in Car-Truck Classification Definitions over time.

Minivan means a light truck which is designed primarily to carry no more than eight passengers, having an integral enclosure fully enclosing the driver, passenger, and load-carrying compartments, and rear seats readily removed, folded, stowed, or pivoted to facilitate cargo carrying. A minivan typically includes one or more sliding doors and a rear liftgate. Minivans typically have less total interior volume or overall height than full sized vans and are commonly advertised and marketed as "minivans."

Mpg means miles per gallon.

Mpge means miles per gasoline gallon equivalent (see gasoline gallon equivalent above).

Pickup truck means a light truck which has a passenger compartment and an open cargo bed.

Plug-in hybrid electric vehicle (PHEV) means a hybrid electric vehicle that has the capability to charge the battery from an off-vehicle electric source, such that the off-vehicle source cannot be connected to the vehicle while the vehicle is in motion.

Special purpose vehicles means automobiles with GVWR less than or equal to 8,500 pounds and medium-duty passenger vehicles which possess special features and which the Administrator determines are more appropriately classified separately from typical automobiles.
For purposes of the Trends report, we used engineering judgment to allocate the very small number of vehicles, labeled as special purpose vehicles at www.fueleconomy.gov, to the three truck types: truck SUV, van/minivan, or truck

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Sport utility vehicle (SUV) means a light truck with an extended roof line to increase cargo or passenger capacity, cargo compartment open to the passenger compartment, and one or more rear seats readily removed or folded to facilitate cargo carrying. Generally, 2-wheel drive SUVs equal to or less than 6000 lbs GVWR are passenger cars for CAFE and GHG standards compliance, but continue to be labeled as SUVs.

Station wagon means cars with an extended roof line to increase cargo or passenger capacity, cargo compartment open to the passenger compartment, a tailgate, and one or more rear seats readily removed or folded to facilitate cargo carrying.

Track width –means the lateral distance between the centerlines of the base tires at ground, including the camber angle.

Van means any light truck having an integral enclosure fully enclosing the driver compartment and load carrying compartment. The distance from the leading edge of the windshield to the foremost body section of vans is typically shorter than that of pickup trucks and SUVs.

Wheelbase is the longitudinal distance between front and rear wheel centerlines.

I. Links for More Information

This report, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2016* (EPA-420-R-16-010) is available on the EPA's Office of Transportation and Air Quality's (OTAQ) web site at: www.epa.gov/fuel-economy/trends-report. The Executive Summary of this report (EPA-420-S-16-001) is available at the same web site.

A copy of the *Fuel Economy Guide* giving city and highway fuel economy data for individual models is available at: www.fueleconomy.gov or by calling the U.S. Department of Energy at (800) 423-1363.

The website www.fueleconomy.gov provides fuel economy and environmental information for vehicles from model year 1984 through the present. The site has many tools that allow users to search for vehicles and find information on vehicle fuel economy, fuel consumption, estimated annual fuel cost, and CO_2 emissions. The site also allows users to personalize fuel economy and fueling cost estimates based on personalized inputs for fuel cost, annual mileage, and percentage of city versus highway driving.

EPA's Green Vehicle Guide (www.epa.gov/greenvehicles) is designed to help car buyers identify the cleanest, most fuel-efficient vehicle that meets their needs. The site includes information on SmartWay certified vehicles, how advanced technology vehicles work, and infographics and videos that provide tips on saving money and reducing emissions through smarter vehicle choices.

For detailed information about EPA's GHG emissions standards for motor vehicles, see: www.epa.gov/regulations-emissions-vehicles-and-engines.

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For information about automaker compliance with EPA's Greenhouse Gas Emissions standards, including a detailed Manufacturer Performance Report for the 2015 Model Year, see: www.epa.gov/regulations-emissions-vehicles-and-engines/ghg-emission-standards-light-duty-vehicles-manufacturer.

For detailed information about DOT's Corporate Average Fuel Economy (CAFE) program, including a program overview, related rulemaking activities, and summaries of the formal CAFE performance of individual manufacturers since 1978, see: www.nhtsa.gov/Laws-&-Regulations/CAFE---Fuel-Economy.

For more information about the EPA/Department of Transportation (DOT) Fuel Economy and Environment Labels, see: www.epa.gov/greenvehicles/learn-about-fuel-economy-label.

J. AUTHORS AND ACKNOWLEDGEMENTS

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Notes:

*Historic vehicle size classifications are retained in selected appendices for MY 1975-2011, though they are no longer discussed in the body of the report. See table below for size thresholds by historic vehicle type:

	Car Interior Volume (cubic feet)	Wagon Interior Volume (cubic feet)	Car SUV Wheelbase (inches)	Truck SUV Wheelbase (inches)	Pickup Wheelbase (inches)	Van/Minivan Wheelbase (inches)
Small	<=109	<=129	<100	<100	<105	<109
Midsize	110-119	130-159	100-110	100-110	105-115	109-124
Large	>= 120	>= 160	>110	>110	>115	>124

†Appendices data stratified by manufacturer do not include some data for Volkswagen for model years 2009-2016 due to an ongoing investigation.

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From:	Good, David [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=6A0A212FAB8644B89798966A2FFF3AB8-GOOD, DAVID]
Sent:	1/8/2021 7:56:31 PM
To:	Diaz, Leah [Diaz.Leah@epa.gov]; Somoza, Sandra [Somoza.Sandra@epa.gov]; Wright, DavidA [Wright.DavidA@epa.gov]; Rojeck, Tristin [rojeck.tristin@epa.gov]
Subject:	RE: Follow-up to today' meeting with CGI folks - Capping Credits [CBI Excel spreadsheet attached]
Attachments:	DRAFT djg-v3-CBI-CAFE-GHG-Off-Cycle 10gpm credit-cap-DPC-IPC-LT example-w-Tesla-JLR-Ford-5-26-2020.xlsm

David & all,

RE: Follow-up to today' meeting with CGI folks - Capping Credits [CBI Excel spreadsheet attached];

Here's a better copy of the CBI Excel spreadsheet developed by Rob & me for capping credits. I revised the previous spreadsheet which I sent a couple days ago---this one now has the correct Tesla unadjusted 2018MY CAFE values.
- GHG capping is done in columns A-H;
- CAFE capping is done in columns K-M;
- Impact on FCIV & CAFE values is in columns O-Q;
- EPA credit capping regulations are in columns U-AE;
- Tab "Sample Data1" contains an example where IPC & DPC credits are both over 10gpm and LT credits are less than 10gpm----which is a rather complicated capping process (for IPC & DPC credits).

I consider it to be CONFIDENTIAL since the Tesla, JLR & Ford data are not generally available to other mfrs or to the general public---even though some of the credit data, etc might be listed in the Trends Reports.

I consider the formulas & capping process to be too complicated to send to the CGI contractor----since it is unproven by the industry and too costly for us (since CGI will need to spend a lot of time to understand the calculations, will have some difficult questions for us (which may take me a lot of time to anwer), etc.)

Dave

From: Good, David
Sent: Wednesday, January 6, 2021 11:24 AM
To: Diaz, Leah <Diaz.Leah@epa.gov>; Somoza, Sandra <Somoza.Sandra@epa.gov>; Wright, DavidA <Wright.DavidA@epa.gov>; Rojeck, Tristin <rojeck.tristin@epa.gov>
Subject: Capping Credits

Stay safe

Dave
734-646-0033 (cell)

Tuesday, November 17, 2020

CAFE/GHG Letter Number: 2017-LD-TSL-PV-3212

Suraj Nagaraj
VP/Senior Official
Tesla Motors
3500 Deer Creek Road
Palo Alto, California   94304
United States

This letter serves to formally acknowledge the receipt of your 2017 Corporate Average Fuel Economy (CAFE) calculation and Corporate Average Greenhouse Gas (GHG) calculation for passenger vehicles.

In accordance with 40 CFR 600.510-12, we have calculated domestic and import passenger vehicle CAFE values and passenger vehicle GHG and GHG Temporary Lead-time Allowance Alternative Standards (TLAAS) values. The manufacturer-submitted and EPA-calculated values for these calculations and the calculated footprint-based standards are shown on the enclosed 'CAFE/GHG Calculation Information Report'. The report includes CAFE and GHG calculations with and without dual-fuel/alt-fuel credits, but does not include any other type of CAFE or GHG credit.

The calculated CAFE value may (if applicable) include an increase in average fuel economy value attributed to manufacturing incentives for alternative fuel and dual-fuel automobiles, reference 49 U.S.C. 32905. The provisions of 49 U.S.C. 32906 limit the maximum increase attributed to dual fuel vehicles to 0.6 mpg for the 2017 model year calculation.

Any additional CAFE or GHG credits for the model year, as well as any additional EPA comments, are shown on the enclosed 'CAFE/GHG Credits and Debits Report'.

Sincerely,

Linc Wehrly, Director
Compliance Division

CAFE/GHG Credits and Debits Report

The GHG credits and debits for vehicles produced in this model year are listed below. GHG credits may be accrued by manufacturers for vehicles produced with advanced CO2 reducing technology, reduced air conditioning refrigerant leakage, improved air conditioning efficiency, and improved off-cycle CO2 emissions.

GHG debits may be accrued by manufacturers for cases where vehicles are allowed to exceed nominal methane levels and/or nitrous oxide levels.

GHG: Greenhouse Gas credits and/or debits for 2017 model year Tesla Inc. Passenger Cars as reported to and confirmed by EPA are as follows (in Megagrams):

For vehicles certified to the Primary Program Standards in 40 CFR 86.1818-12(c):

Ex. 4 CBI

CAFE: Fleet average CAFE MPG values and credit information for 2017 model year Tesla Inc. Passenger Cars as reported to and confirmed by EPA are as follows:

Domestic Passenger Cars:

Ex. 4 CBI

EPA Official Final CAFE MPG Value (including Credits): Ex. 4 CBI

EPA Official CAFE MPG Standard (Footprint-based): Ex. 4 CBI

Import Passenger Cars: Not Applicable

**********IMPORTANT INFORMATION**********

This letter provides revised 2017 model year Greenhouse Gas (GHG) information in this letter and the attached CAFE/GHG Information Report. The GHG information provided in this letter and the attached CAFE/GHG Information Report reflects recent regulation changes made in the EPA Light-Duty Vehicle Greenhouse Gas Program Technical Amendments (Multiplier) final rule; ref. 85 FR 22609, April 23, 2020. No changes have been made to the 2017 CAFE values provided in EPA's previous CAFE/GHG letter.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
NATIONAL VEHICLES AND FUEL EMISSIONS LABORATORY
2000 TRAVERWOOD DRIVE
ANN ARBOR, MICHIGAN 48105

Tuesday, November 17, 2020

CAFE/GHG Letter Number: 2018-LD-TSL-LT-3211

Suraj Nagaraj
VP/Senior Official
Tesla Motors
3500 Deer Creek Road
Palo Alto, California 94304
United States

This letter serves to formally acknowledge the receipt of your 2018 Corporate Average Fuel Economy (CAFE) calculation and Corporate Average Greenhouse Gas (GHG) calculation for light trucks.

In accordance with 40 CFR 600.510-12, we have calculated light truck CAFE values and light truck GHG and GHG Temporary Lead-time Allowance Alternative Standards (TLAAS) values. The manufacturer-submitted and EPA-calculated values for these calculations and the calculated footprint-based standards are shown on the enclosed 'CAFE/GHG Calculation Information Report'. The report includes CAFE and GHG calculations with and without dual-fuel/alt-fuel credits, but does not include any other type of CAFE or GHG credit.

The calculated CAFE value may (if applicable) include an increase in average fuel economy value attributed to manufacturing incentives for alternative fuel and dual-fuel automobiles, reference 49 U.S.C. 32905. The provisions of 49 U.S.C. 32906 limit the maximum increase attributed to dual fuel vehicles to 0.4 mpg for the 2018 model year calculation.

Any additional CAFE or GHG credits for the model year, as well as any additional EPA comments, are shown on the enclosed 'CAFE/GHG Credits and Debits Report'.

Sincerely,

Linc Wehrly, Director
Compliance Division

CAFE/GHG Credits and Debits Report

The GHG credits and debits for vehicles produced in this model year are listed below. GHG credits may be accrued by manufacturers for vehicles produced with advanced CO_2 reducing technology, reduced air conditioning refrigerant leakage, improved air conditioning efficiency, and improved off-cycle CO_2 emissions.

GHG debits may be accrued by manufacturers for cases where vehicles are allowed to exceed nominal methane levels and/or nitrous oxide levels.

GHG: Greenhouse Gas credits and/or debits for 2018 model year Tesla Inc. Light Trucks as reported to and confirmed by EPA are as follows (in Megagrams):

For vehicles certified to the Primary Program Standards in 40 CFR 86.1818-12(c):

885

Ex. 4 CBI

Tot

CAFE: Fleet average CAFE MPG values and credit information for 2018 model year Tesla Inc. Light Trucks as reported to and confirmed by EPA are as follows:

Light Trucks:

Ex. 4 CBI

EPA Official Final CAFE MPG Value (including Credits): Ex. 4 CBI

EPA Official CAFE MPG Standard (Footprint-based): Ex. 4 CBI

Tuesday, November 17, 2020

CAFE/GHG Letter Number: 2018-LD-TSL-PV-3210

Suraj Nagaraj
VP/Senior Official
Tesla Motors
3500 Deer Creek Road
Palo Alto, California 94304
United States

This letter serves to formally acknowledge the receipt of your 2018 Corporate Average Fuel Economy (CAFE) calculation and Corporate Average Greenhouse Gas (GHG) calculation for passenger vehicles.

In accordance with 40 CFR 600.510-12, we have calculated domestic and import passenger vehicle CAFE values and passenger vehicle GHG and GHG Temporary Lead-time Allowance Alternative Standards (TLAAS) values. The manufacturer-submitted and EPA-calculated values for these calculations and the calculated footprint-based standards are shown on the enclosed 'CAFE/GHG Calculation Information Report'. The report includes CAFE and GHG calculations with and without dual-fuel/alt-fuel credits, but does not include any other type of CAFE or GHG credit.

The calculated CAFE value may (if applicable) include an increase in average fuel economy value attributed to manufacturing incentives for alternative fuel and dual-fuel automobiles, reference 49 U.S.C. 32905. The provisions of 49 U.S.C. 32906 limit the maximum increase attributed to dual fuel vehicles to 0.4 mpg for the 2018 model year calculation.

Any additional CAFE or GHG credits for the model year, as well as any additional EPA comments, are shown on the enclosed 'CAFE/GHG Credits and Debits Report'.

Sincerely,

Linc Wehrly, Director
Compliance Division

CAFE/GHG Credits and Debits Report

The GHG credits and debits for vehicles produced in this model year are listed below. GHG credits may be accrued by manufacturers for vehicles produced with advanced CO2 reducing technology, reduced air conditioning refrigerant leakage, improved air conditioning efficiency, and improved off-cycle CO2 emissions.

GHG debits may be accrued by manufacturers for cases where vehicles are allowed to exceed nominal methane levels and/or nitrous oxide levels.

GHG: Greenhouse Gas credits and/or debits for 2018 model year Tesla Inc. Passenger Cars as reported to and confirmed by EPA are as follows (in Megagrams):

For vehicles certified to the Primary Program Standards in 40 CFR 86.1818-12(c):

Ex. 4 CBI

Total

CAFE: Fleet average CAFE MPG values and credit information for 2018 model year Tesla Inc. Passenger Cars as reported to and confirmed by EPA are as follows:

Domestic Passenger Cars:

Ex. 4 CBI

EPA Official Final CAFE MPG Value (including Credits): Ex. 4 CBI

EPA Official CAFE MPG Standard (Footprint-based): Ex. 4 CBI

Import Passenger Cars: Not Applicable

Tuesday, November 17, 2020

CAFE/GHG Letter Number: 2019-LD-TSL-LT-3209

Suraj Nagaraj
VP/Senior Official
Tesla Motors
3500 Deer Creek Road
Palo Alto, California   94304
United States

This letter serves to formally acknowledge the receipt of your 2019 Corporate Average Fuel Economy (CAFE) calculation and Corporate Average Greenhouse Gas (GHG) calculation for light trucks.

In accordance with 40 CFR 600.510-12, we have calculated light truck CAFE values and light truck GHG and GHG Temporary Lead-time Allowance Alternative Standards (TLAAS) values. The manufacturer-submitted and EPA-calculated values for these calculations and the calculated footprint-based standards are shown on the enclosed 'CAFE/GHG Calculation Information Report'. The report includes CAFE and GHG calculations with and without dual-fuel/alt-fuel credits, but does not include any other type of CAFE or GHG credit.

The calculated CAFE value may (if applicable) include an increase in average fuel economy value attributed to manufacturing incentives for alternative fuel and dual-fuel automobiles, reference 49 U.S.C. 32905. The provisions of 49 U.S.C. 32906 limit the maximum increase attributed to dual fuel vehicles to 0.2 mpg for the 2019 model year calculation.

Any additional CAFE or GHG credits for the model year, as well as any additional EPA comments, are shown on the enclosed 'CAFE/GHG Credits and Debits Report'.

Sincerely,

Linc Wehrly, Director
Compliance Division

ED_006488A_00003707-00001

CAFE/GHG Credits and Debits Report

The GHG credits and debits for vehicles produced in this model year are listed below. GHG credits may be accrued by manufacturers for vehicles produced with advanced CO2 reducing technology, reduced air conditioning refrigerant leakage, improved air conditioning efficiency, and improved off-cycle CO2 emissions.

GHG debits may be accrued by manufacturers for cases where vehicles are allowed to exceed nominal methane levels and/or nitrous oxide levels.

GHG: Greenhouse Gas credits and/or debits for 2019 model year Tesla Inc. Light Trucks as reported to and confirmed by EPA are as follows (in Megagrams):

For vehicles certified to the Primary Program Standards in 40 CFR 86.1818-12(c):

Ex. 4 CBI

Tot

CAFE: Fleet average CAFE MPG values and credit information for 2019 model year Tesla Inc. Light Trucks as reported to and confirmed by EPA are as follows:

Light Trucks:

Ex. 4 CBI

EPA Official Final CAFE MPG Value (including Credits): Ex. 4 CBI

EPA Official CAFE MPG Standard (Footprint-based): Ex. 4 CBI

Tuesday, November 17, 2020

CAFE/GHG Letter Number: 2019-LD-TSL-PV-3208

Suraj Nagaraj
VP/Senior Official
Tesla Motors
3500 Deer Creek Road
Palo Alto, California   94304
United States

This letter serves to formally acknowledge the receipt of your 2019 Corporate Average Fuel Economy (CAFE) calculation and Corporate Average Greenhouse Gas (GHG) calculation for passenger vehicles.

In accordance with 40 CFR 600.510-12, we have calculated domestic and import passenger vehicle CAFE values and passenger vehicle GHG and GHG Temporary Lead-time Allowance Alternative Standards (TLAAS) values. The manufacturer-submitted and EPA-calculated values for these calculations and the calculated footprint-based standards are shown on the enclosed 'CAFE/GHG Calculation Information Report'. The report includes CAFE and GHG calculations with and without dual-fuel/alt-fuel credits, but does not include any other type of CAFE or GHG credit.

The calculated CAFE value may (if applicable) include an increase in average fuel economy value attributed to manufacturing incentives for alternative fuel and dual-fuel automobiles, reference 49 U.S.C. 32905. The provisions of 49 U.S.C. 32906 limit the maximum increase attributed to dual fuel vehicles to 0.2 mpg for the 2019 model year calculation.

Any additional CAFE or GHG credits for the model year, as well as any additional EPA comments, are shown on the enclosed 'CAFE/GHG Credits and Debits Report'.

Sincerely,

Linc Wehrly, Director
Compliance Division

CAFE/GHG Credits and Debits Report

The GHG credits and debits for vehicles produced in this model year are listed below. GHG credits may be accrued by manufacturers for vehicles produced with advanced CO2 reducing technology, reduced air conditioning refrigerant leakage, improved air conditioning efficiency, and improved off-cycle CO2 emissions.

GHG debits may be accrued by manufacturers for cases where vehicles are allowed to exceed nominal methane levels and/or nitrous oxide levels.

GHG: Greenhouse Gas credits and/or debits for 2019 model year Tesla Inc. Passenger Cars as reported to and confirmed by EPA are as follows (in Megagrams):

For vehicles certified to the Primary Program Standards in 40 CFR 86.1818-12(c):

Ex. 4 CBI

Total

CAFE: Fleet average CAFE MPG values and credit information for 2019 model year Tesla Inc. Passenger Cars as reported to and confirmed by EPA are as follows:

Domestic Passenger Cars:

Ex. 4 CBI

EPA Official Final CAFE MPG Value (including Credits): Ex. 4 CBI

EPA Official CAFE MPG Standard (Footprint-based): Ex. 4 CBI

Import Passenger Cars: Not Applicable

From:	Good, David [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=6A0A212FAB8644B89798966A2FFF3AB8-GOOD, DAVID]
Sent:	11/30/2020 5:17:46 PM
To:	Wolkins, Jed [wolkins.jed@epa.gov]
CC:	Ex. 6 Personal Privacy (PP)
Subject:	FW: Request for Test Procedure Description, Acronyms and Instructions for Fuel Economy Test Data Files 2020
Attachments:	autoengine2020.xlsx

Jed & all,

The list of terms can be found at https://www.epa.gov/sites/production/files/2016-07/documents/test-car-list-definitions.pdf which came from https://www.epa.gov/compliance-and-fuel-economy-data/description-and-instructions-fuel-economy-test-data-files which came from https://www.epa.gov/compliance-and-fuel-economy-data/data-cars-used-testing-fuel-economy.

Unfortunately, that document doesn't answer Simi's questions. Here are your answers:

"Both" means that both cars and trucks were included in the test group in column I of your spreadsheet.

The Test Procedure (code and description) outlined in column's AH and AI of the attached spreadsheet are as follows:

*****Test Procedure****************

Code	Description	Comment
2 =	CVS 75 AND LATER (W/O CAN. LOAD)	FTP (city test procedure at 68-86 deg F) with no canister loading procedure (used mostly for diesel vehicles)
3 =	HWFE (HIGHWAY TEST)	Highway test
9 =	HWY80 (80 MPH HIGHWAY TEST)	
10 =	IDLE CO	
11 =	COLD CO	Cold FTP (city test procedure at 20 deg F)
15 =	SPITBACK TEST	
16 =	Hot 1435 LA92	
21 =	FED FUEL 2 DAY EXH (BUTANE LOAD)	FTP (city test procedure at 68-86 deg F) using 2-day (2 gram break-thru) canister loading procedure
23 =	FED FUEL 2 DAY EVAP (BUTANE)	Federal 2-Day Evap Test Procedure using Federal Test Fuel (9RVP) and the 2-day (2 gram break-thru) canister loading procedure for the FTP portion of the test
24 =	FED FUEL REFUEL (ORVR) (BUTANE)	ORVR (refueling) test procedure
25 =	CA FUEL 2 DAY EXH (BUTANE LOAD)	FTP (city procedure at 68-86 deg F) using Calif Lev2 or LEV3 test fuel with a 2-day (2 gram break-thru) canister loading procedure
27 =	CA FUEL 2 DAY EVAP (BUTANE LOAD)	Calif 2-Day Evap Test Procedure using Calif LEV2 or LEV3 Test Fuel (7RVP) and the 2-day (2 gram break-thru) canister loading procedure for the FTP portion of the test
31 =	FED FUEL 3 DAY EXH (BUTANE LOAD)	FTP (city test procedure at 68-86 deg F) using 3-day (12 hour) canister loading procedure
32 -	FED FUEL RUNNING LOSS	Federal Running Loss Test (part of the 3-day Evap test Procedure)
34 =	FED FUEL 3 DAY EVAP(BUTANE LOAD)	Federal 3-Day Evap Test Procedure using Federal Test Fuel (9RVP) and the 12-hour canister loading procedure for the FTP portion of the test
35 =	CA FUEL 3 DAY EXH (BUTANE LOAD)	FTP (city test procedure at 68-86 deg F) using Calif LEV2 or LEV3 Test Fuel and the 12-hour canister loading procedure
37 =	CA FUEL RUNNING LOSS	Calif Running Loss Test (part of the Calif 3-day Evap test Procedure)
38 =	CA FUEL 3 DAY EVAP (BUTANE LOAD)	Calif 3-Day Evap Test Procedure using CARB Test Fuel (7RVP) and the 12-hour canister loading procedure for the FTP portion of the test
41 =	FED FUEL 2 DAY EXH(HEAT TO LOAD)	

43 = FED FUEL 2DAY EVAP(HEAT TO LOAD)
44 = FED REFUEL (ORVR) (HEAT TO LOAD)
45 = CA FUEL 2 DAY EXH (HEAT TO LOAD)
47 = CA FUEL 2 DAY EVAP(HEAT TO LOAD)
51 = CA FUEL 50 DEG(F) EXHAUST TEST
52 = FED FUEL 50 DEG(F) EXHAUST TEST
60 = AC17 - MANUAL A/C CONTROLS
61 = AC17 - AUTOMATIC A/C CONTROLS
64 = EVAP CARB FUEL ONLY (RIG) TEST
65 = EVAP CANISTER BLEED TEST
66 = LEAK TEST - EVAP FUEL SYSTEM OBD
67 = LEAK TEST - PORT NEAR CANISTER
68 = LEAK TEST - PORT NEAR FUEL PIPE
69 = LEAK TEST - EVAP GAS CAP
72 = CST TWO SPEED IDLE TEST
76 = CST PRECD 2 SPD IDLE (EPA ONLY)
81 = Charge Depleting UDDS   Charge Depleting UDDS (city) Test---used for BEVs & PHEVs
83 = Charge Depleting US06   Charge Depleting US06 Test---used for BEVs & PHEVs
84 = Charge Depleting Highway   Charge Depleting Highway Test---used for BEVs & PHEVs
85 = Charge Depleting SC03
86 = Charge Depleting 20 Degree F FTP   Charge Depleting 20 deg F (Cold Temperature) UDDS (city) Test---used
for BEVs & PHEVs
87 = A/C Idle Test- Manual A/C
88 = A/C Idle Test- Automatic A/C
90 = US06   US06 Test (with higher speeds & harder accelerations)
95 = SC03   SC03 Test (similar to FTP (city) test at 95 deg F ambient with solar
loading)
96 = US06 Bag 2 Only

Hope this helps.

Stay safe

Dave Good, Engineer
U.S. EPA
734-646-0033 (cell)

David,
Can you help answer these questions?

Jed D. Wolkins
Missouri State Manager, Regional Haze and Mobile Lead
Air and Radiation Division
EPA Region 7
913-551-7588

From Ex. 6 Personal Privacy (PP)

Sent: Wednesday, November 25, 2020 1:01 PM
To: Wolkins, Jed <wolkins.jed@epa.gov>
Cc Ex. 6 Personal Privacy (PP)
Subject: Request for Description, Acronyms and Instructions for Fuel Economy Test Data Files 2020

Good afternoon Mr. Wolkins.

I attached a copy of the Excel spreadsheet in question titled 'autoengine2020'. Also CC'd the researcher in question so you can reach out directly in case additional clarification is needed.
See below for the initial email sent to EPA requesting further information complete with link where Excel document was sourced.
Thank you for your kind assistance.

Ex. 6 Personal Privacy (PP)

Hello Sir/Ma'am,

I would like to request for the updated description, acronyms and instructions for fuel economy test data files 2020 downloaded from the following web link:

Data on Cars used for Testing Fuel Economy | US EPA
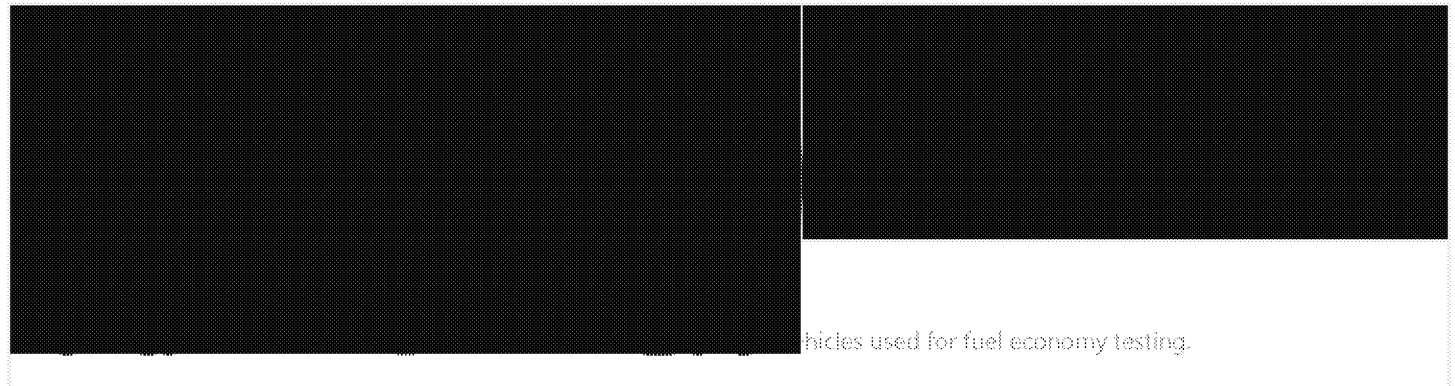
For instance in the 2020 car test data, does "both" under vehicle type imply both cars and SUVS/trucks? What does HWFE and Federal fuel 2-day exhaust (w/can load) mean

under test procedure description?

Looking forward to your prompt response.

Best regards.

From:	Good, David [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=6A0A212FAB8644B89798966A2FFF3AB8-GOOD, DAVID]
Sent:	12/8/2020 6:39:56 PM
To:	Rojeck, Tristin [rojeck.tristin@epa.gov]
CC:	Hula, Aaron [Hula.Aaron@epa.gov]
Subject:	FW: question on EPA 2019 GHG Trend Report
Attachments:	2019 GHG Trend Report.pdf

Importance: High

Tristin or Aaron,

I'm not sure who I should forward this Trends question to.

Can one of you get back to Yasumi, when you get a chance?

Thanks

Stay safe

Dave
734-646-0033 (cell)

From: Nakamura-Newbraugh, Yasumi <yasumi.nakamura-newbraugh@Nissan-Usa.com>
Sent: Monday, December 7, 2020 1:45 PM
To: Good, David <good.david@epa.gov>
Subject: question on EPA GHG Trend Report
Importance: High

Hi Dave,

Hope all is well.

We have some questions related to what was in the **2019 GHG Trend Report**...

Just trying to figure out...

• why a few OEMs did not earn any own credits in MY18 (Table 5.17), but have some credits left in MY23 (Table 5.18)? We assume because those OEMs purchased some MY18 credits from others and the purchased amount is hidden under their credits purchase/sold total (Table 5.17)...

• If that's the case, the total credits earned (total of positive balances) MY18 for the industry (Table 5.17) should match with the total credits expiring in MY23 for the industry (Table 5.18)....but they don't....why? What are we missing?

Table 5.17. Final Credit Balance by Manufacturer for Model Year 2018 (Mg)

Manufacturer	Early Credits Earned 2009-2011	Credits Earned 2012-2017	Credits Earned 2018	Credits Expired	Credits Forfeited	Credits Purchased or Sold*	Final 2018 Credit Balance
BMW	1,261,522	324,909	-416,713	-134,791		5,500,000	6,424,927
BYD Motors		5,400	168				5,568
Coda		7,251				-7,251	
FCA	10,827,083	-22,967,481	-9,396,315			45,054,999	23,518,286
Ford	16,116,453	6,154,294	-3,762,524	-6,882,011			12,626,212
GM	25,788,547	1,216,402	-1,929,023	-6,998,699		7,251	18,084,478
Honda	35,842,334	44,423,035	8,598,273	-14,133,353		-34,245,245	40,485,044
Hyundai	14,007,495	8,833,667	-3,011,849	-4,482,649	-163,775		15,176,889
Jaguar Land Rover		-2,869,661	-4,901			2,722,736	-151,826
Karma Automotive		58,852				-2,841	56,011
Kia	10,444,192	-2,990,314	-1,649,692	-2,362,882	-123,956		3,317,348
Mazda	5,482,642	6,335,942	-385,089	-1,340,917			10,092,578
Mercedes	378,272	-6,004,114	-2,974,379		-28,416	8,727,713	99,076
Mitsubishi	1,449,336	1,227,844	203,923	-583,146		0	2,297,957
Nissan	18,131,200	19,527,625	-2,567,935	-8,190,124		-3,545,570	23,355,196
Porsche		426,439			-426,439		
Subaru	5,756,171	11,636,165	1,533,010	-491,789			18,432,557
Suzuki	876,650	-183,097		-265,311		-428,242	
Tesla	49,772	10,870,056	17,869,526			-17,831,311	10,958,043
Toyota	80,435,498	28,579,728	-5,617,632	-29,732,098		-10,262,431	63,403,065
Volkswagen	6,613,985	-4,247,838	-1,729,374	-1,442,671	-219,419	4,000,000	2,974,785
Volvo	730,187	-380,789	791,296		-85,163		1,055,531
All Manufacturers	234,180,339	99,884,317	-4,449,230	-76,040,341	-1,053,168	(310,192)	252,211,725

* The transactions do not net to zero due to transactions with small volume manufacturers excluded from this report.

Table 5.18
Distribution of Credits by Expiration Date (Mg)

Manufacturer	Final 2018 Credit Balance	Credits Expiring in 2021	Credits Expiring in 2022	Credits Expiring in 2023	Deficit Carried 1 year	Deficit Carried 2 years
BMW	6,424,927	2,623,676	3,656,011	145,240		
BYD Motors	5,568	4,871	529	168		
FCA	23,518,286	12,870,920	2,419,871	8,227,495		
Ford	12,626,212	12,626,212	0	0		
GM	18,084,478	15,044,507	2,286,419	753,552		
Honda	40,485,044	27,814,774	4,071,997	8,598,273		
Hyundai	15,176,889	15,176,889	0	0		
Jaguar Land Rover	-151,826	0	0	0	-5,581	-146,245
Karma Automotive	56,011	56,011	0	0		
Kia	3,317,348	3,317,348	0	0		
Mazda	10,092,578	9,724,291	171,051	197,236		
Mercedes	99,076	99,076	0	0		
Mitsubishi	2,297,957	1,922,105	171,929	203,923		
Nissan	23,355,196	22,846,419	508,777	0		
Subaru	18,432,557	12,706,379	3,191,237	2,534,941		
Tesla	10,958,043	0	2,316,012	8,642,031		
Toyota	63,403,065	59,063,588	2,228,712	2,110,765		
Volkswagen	2,974,785	1,730,640	0	1,244,145		
Volvo	1,055,531	0	264,235	791,296		
All Manufacturers	252,211,725	197,627,706	21,286,780	33,449,065	-5,581	-146,245

Thank you!

Yasumi Nakamura-Newbraugh
Manager, Environment

Government Affairs

Nissan Group of North America
Phone: 240-731-8428

NISSAN
GROUP OF NORTH AMERICA
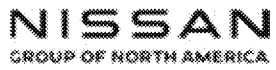
The 2019

EPA Automotive Trends Report

Greenhouse Gas Emissions,
Fuel Economy, and
Technology since 1975

NOTICE: This technical report does not necessarily represent final EPA decisions, positions, or approval or validation of compliance data reported to EPA by manufacturers. It is intended to present technical analysis of issues using data that are currently available and that may be subject to change. The purpose of the release of such reports is to facilitate the exchange of technical information and to inform the public of technical developments.

These data reflect the most current available data. Historic data have been adjusted, when appropriate, to reflect the result of compliance investigations by EPA or any other corrections necessary to maintain data integrity. This edition of the report supersedes all previous versions.

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1. Introduction

This annual report is part of the U.S. Environmental Protection Agency's (EPA) commitment to provide the public with information about new light-duty vehicle greenhouse gas (GHG) emissions, fuel economy, technology data, and auto manufacturers' performance in meeting the agency's GHG emissions standards.

EPA has collected data on every new light-duty vehicle model sold in the United States since 1975, either from testing performed by EPA at the National Vehicle Fuel and Emissions Laboratory in Ann Arbor, Michigan, or directly from manufacturers using official EPA test procedures. These data are collected to support several important national programs, including EPA criteria pollutant and GHG standards, the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) Corporate Average Fuel Economy (CAFE) standards, and vehicle Fuel Economy and Environment labels. This expansive data set allows EPA to provide a uniquely comprehensive analysis of the automotive industry over the last 40 plus years.

A. What's New This Year

- Tesla increased production in model year 2018 to over 190,000 vehicles, or four times the production achieved in model year 2017. Because this report uses a production threshold of 150,000 vehicles for many tables and figures, Tesla has accordingly been added to these tables and figures.

- Nissan and Mitsubishi are considered separate corporate entities throughout this report. In 2016, Nissan purchased a controlling share of Mitsubishi, and NHTSA took initial action requiring Nissan and Mitsubishi be combined for compliance under the CAFE program (which EPA would follow for the GHG program). The previous edition of this report combined Nissan and Mitsubishi, however NHTSA has since determined that these two companies will in fact remain separate for regulatory purposes.

- The website for this report has been expanded with an emphasis on allowing users to access and evaluate more of the data behind this report. We encourage readers to visit our website at https://www.epa.gov/automotive-trends and explore the data. EPA will continue to add content and tools on the web to allow transparent access to public data.

The content in this report was previously published in two separate reports, the *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends Report*, and the *GHG Manufacturer Performance Report*. These reports were combined, starting with the 2018 report, to provide a more comprehensive analysis.

The overall long-term trends in the light-duty automotive industry since 1975 are explored in Section 2. Section 3 focuses on trends in vehicle parameters such as vehicle type, weight, horsepower, acceleration, and footprint. Section 4 examines industry trends by engine and transmission technologies. The status of manufacturer compliance with the GHG standards is included in Section 5. Additional data and methodology discussions are included in the appendices. This report supersedes all previous reports and should not be compared to past reports.

B. Manufacturers in this Report

The underlying data for this report include every new light-duty vehicle offered for sale in the United States. These data are presented by manufacturer throughout this report, using the model year 2018 manufacturer definitions determined by EPA and NHTSA for implementation of the GHG emission standards and CAFE program. For simplicity, many figures and tables throughout the report show only the 14 manufacturers that produced at least 150,000 vehicles in the 2018 model year. These manufacturers account for approximately 98% of all production. Table 1.1 lists the 14 manufacturers and their associated makes, along with an "other" category that captures the remaining manufacturers.

When a manufacturer grouping changes under the GHG and CAFE programs, EPA makes the same change in this report. For the analysis of estimated real-world CO_2 emission and fuel economy trends in Sections 1 through 4, EPA applies the current manufacturer definitions to all prior model years. This maintains consistent manufacturer and make definitions over time, which enables better identification of long-term trends. However, the compliance data that are discussed in Section 5 of this report maintain the previous manufacturer definitions where necessary to preserve the integrity of compliance data as accrued.

Table 1.1. Manufacturer Definitions

Manufacturer	Makes in the U.S. Market
BMW	BMW, Mini, Rolls Royce
FCA	Alfa Romeo, Chrysler, Dodge, Fiat, Jeep, Maserati, Ram
Ford	Ford, Lincoln, Roush, Shelby
GM	Buick, Cadillac, Chevrolet, GMC
Honda	Acura, Honda
Hyundai	Genesis, Hyundai
Kia	Kia
Mazda	Mazda
Mercedes	Maybach, Mercedes, Smart
Nissan	Infiniti, Nissan
Subaru	Subaru
Tesla	Tesla
Toyota	Lexus, Scion, Toyota
Volkswagen	Audi, Bentley, Bugatti, Lamborghini, Porsche, Volkswagen
Other[1]	Aston Martin, Ferrari, Jaguar, Land Rover, Lotus, McLaren, Mitsubishi, Volvo

C. Fuel Economy and CO_2 Metrics in this Report

All data in this report for model years 1975 through 2018 are **final** and based on official data submitted to EPA and NHTSA as part of the regulatory process. In some cases, this report will show data for model year 2019, which are **preliminary** and based on data provided to EPA by automakers prior to the model year. Preliminary data is not shown for manufacturer compliance. All data in this report are based on production volumes delivered for sale in the U.S. by model year. The model year production volumes may vary from other publicized data based on calendar year sales. The report does not examine future model years, and past performance does not necessarily predict future industry trends.

The carbon dioxide (CO_2) emissions and fuel economy data in this report fall into one of two categories based on the purpose of the data and the subsequent required emissions test procedures.

The first category is **compliance** data, which is measured using laboratory tests required by law for CAFE and adopted by EPA for GHG compliance. Compliance data are measured using EPA city and highway test procedures (the "2-cycle" tests), and fleetwide averages are

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[1] Only vehicle brands produced in model year 2018 are shown. There are many other manufacturers and brands captured in the "other" category over the course of this report.

calculated by weighting the city and highway test results by 55% and 45%, respectively. These procedures are required for compliance; however, they no longer accurately reflect real-world driving. Compliance data may also encompass credits and other flexibilities that manufacturers can use towards meeting their emissions standards.

The second category is **estimated real-world** (previously called "adjusted") data, which is measured using additional laboratory tests to capture a wider range of operating conditions (including hot/cold weather and higher acceleration) that an average driver will encounter. This expanded set of tests is referred to as "5-cycle" testing. City and highway results are weighted 43% city and 57% highway, consistent with fleetwide driver activity data. The city and highway values are the same values found on new vehicle fuel economy labels, however the label combined value is weighted 55% city and 45% highway. Unlike compliance data, the method for calculating real-world data has evolved over time, along with technology and driving habits.

Table 1.2. Fuel Economy and CO_2 Metrics Used in this Report

CO_2 and Fuel Economy Data Category	Purpose	Current City/Highway Weighting	Current Test Basis
Compliance	Basis for manufacturer compliance with standards	55% / 45%	2-cycle
Estimated Real-World ("adjusted" in previous reports)	Best estimate of real-world performance	43% / 57%	5-cycle

This report will show estimated real-world data except for the discussion specific to the GHG regulations in Section 5 and Executive Summary Figures ES-6 through ES-8. The compliance CO_2 data must not be compared to the real-world CO_2 data presented elsewhere in this report. Appendices C and D present a more detailed discussion of the fuel economy and CO_2 data used in this report.

This report does not provide data about NHTSA's CAFE program. For more information about CAFE and manufacturer compliance with the CAFE fuel economy standards, see the CAFE Public Information Center, which can be accessed at https://one.nhtsa.gov/cafe_pic/CAFE_PIC_Home.htm.

2. Fleetwide Trends Overview

The automotive industry has made strong progress towards lower tailpipe CO_2 emissions and higher fuel economy in recent years. This section provides an update on the estimated real-world tailpipe CO_2 emissions and fuel economy for the overall fleet, and for manufacturers based on final model year 2018 data. The unique, historical data on which this report is based also provide an important backdrop for evaluating the more recent performance of the industry. Using that data, this section will also explore basic fleetwide trends in the automotive industry since EPA began collecting data in model year 1975.

A. Overall Fuel Economy and CO_2 Trends

In model year 2018, the industry achieved record low new vehicle CO_2 emissions and record high fuel economy, as shown in Figure 2.1. Average estimated real-world CO_2 tailpipe emissions fell by 4 g/mi to 353 g/mi, while estimated real-world fuel economy increased 0.2 mpg to 25.1 mpg compared to the previous year.[2] Over the last fourteen years, CO_2 emissions and fuel economy have improved twelve times and worsened twice.

The preliminary average estimated real-world fuel economy of all new model year 2019 vehicles is projected to increase again, to 25.5 mpg with a corresponding decrease in average CO_2 emissions to 346 g/mi. If achieved, these values will be record levels and an improvement over model year 2018.

Figure 2.1. Estimated Real-World Fuel Economy and CO_2 Emissions

The preliminary model year 2019 data are based on production estimates provided to EPA

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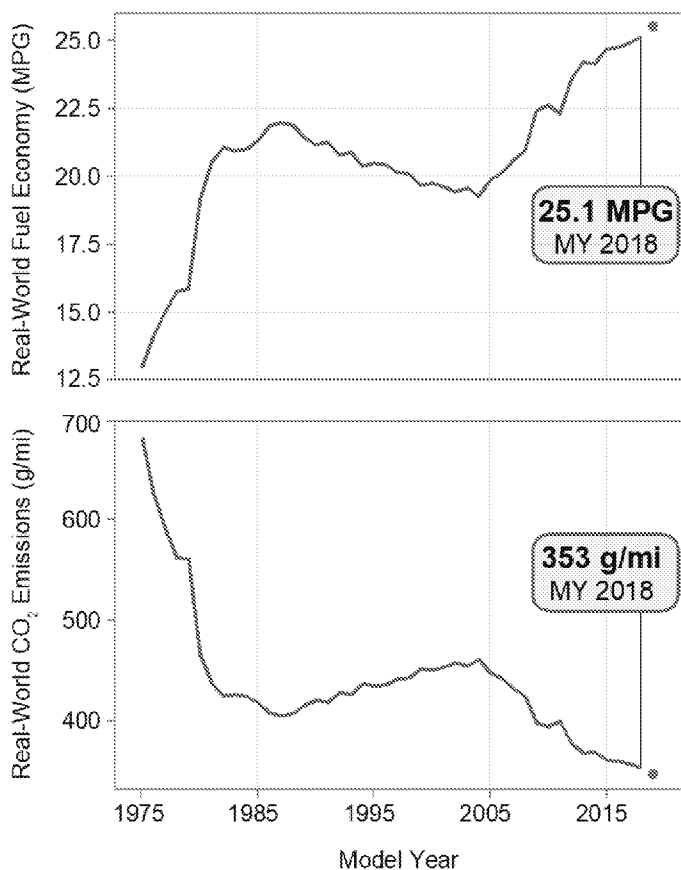
[2] EPA generally uses unrounded values to calculate values in the text, figures, and tables in this report. This approach results in the most accurate data but may lead to small apparent discrepancies due to rounding.

by manufacturers months before the vehicles go on sale. The data are a useful indicator, however there is always uncertainty associated with such projections, and we caution the reader against focusing only on these data.

While the most recent annual changes often receive the most public attention, the greatest value of the Trends database is to document long-term trends. The magnitude of changes in annual CO_2 emissions and fuel economy tend to be small relative to longer, multi-year trends. Figure 2.2 shows fleetwide estimated real-world CO_2 emissions and fuel economy for model years 1975–2018. Over this timeframe there have been three basic phases: 1) a rapid improvement of fuel economy between 1975 and 1987, 2) a period of slowly decreasing fuel economy through 2004, and 3) increasing fuel economy through the current model year. Vehicle CO_2 emissions, which are generally inversely related to fuel economy,[3] have followed the opposite pattern over the same timeframe.

Figure 2.2. Trends in Fuel Economy and CO_2 Emissions Since Model Year 1975

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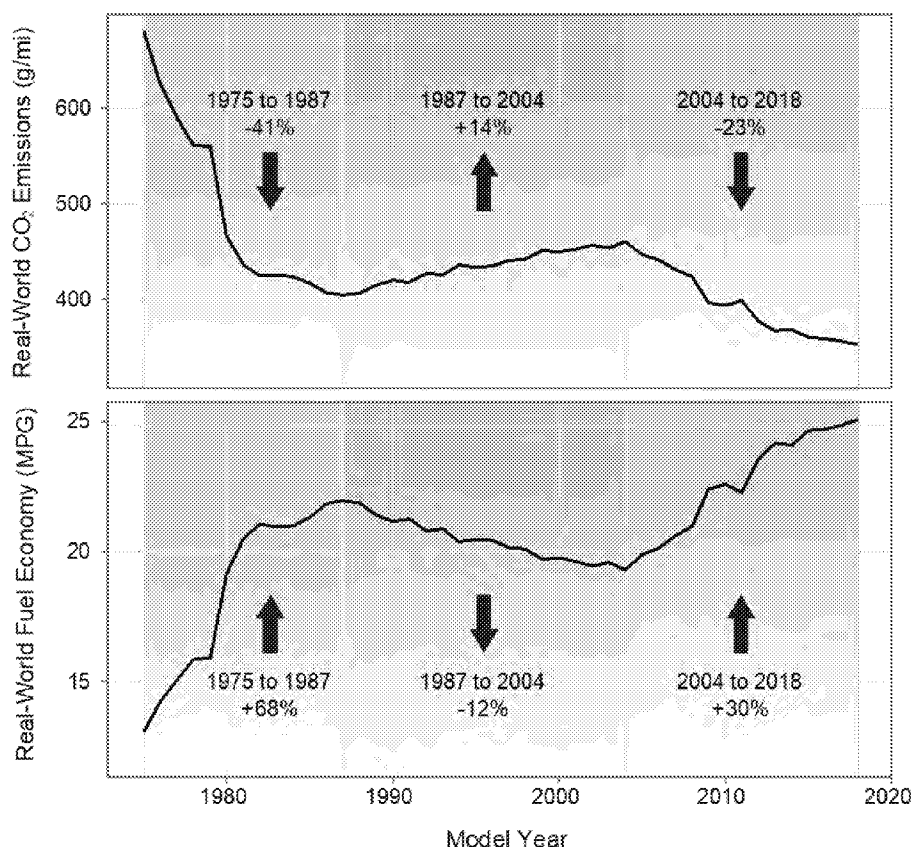
[3] Fuel economy and CO_2 emissions are inversely related for gasoline and diesel vehicles, but not for electric vehicles (which have zero tailpipe emissions). If electric vehicles begin to capture a larger market share, the overall relationship between fuel economy and tailpipe CO_2 emissions will change.

Another way to look at CO_2 emissions over time is to examine how the distribution of new vehicle emission rates have changed. Figure 2.3 shows the distribution of real-world tailpipe CO_2 emissions for all vehicles produced within each model year. Half of the vehicles produced each year are clustered within a small band around the median CO_2 emission rate, as shown in blue. The remaining vehicles show a much wider spread, especially in the best and worst 5% of production each year. The lowest CO_2-emitting vehicles have all been hybrids or electric vehicles since the first hybrid was introduced in model year 2000. The highest CO_2-emitting vehicles are generally low volume performance vehicles or large trucks.

Figure 2.3. Distribution of New Vehicle CO_2 Emissions by Model Year[4]
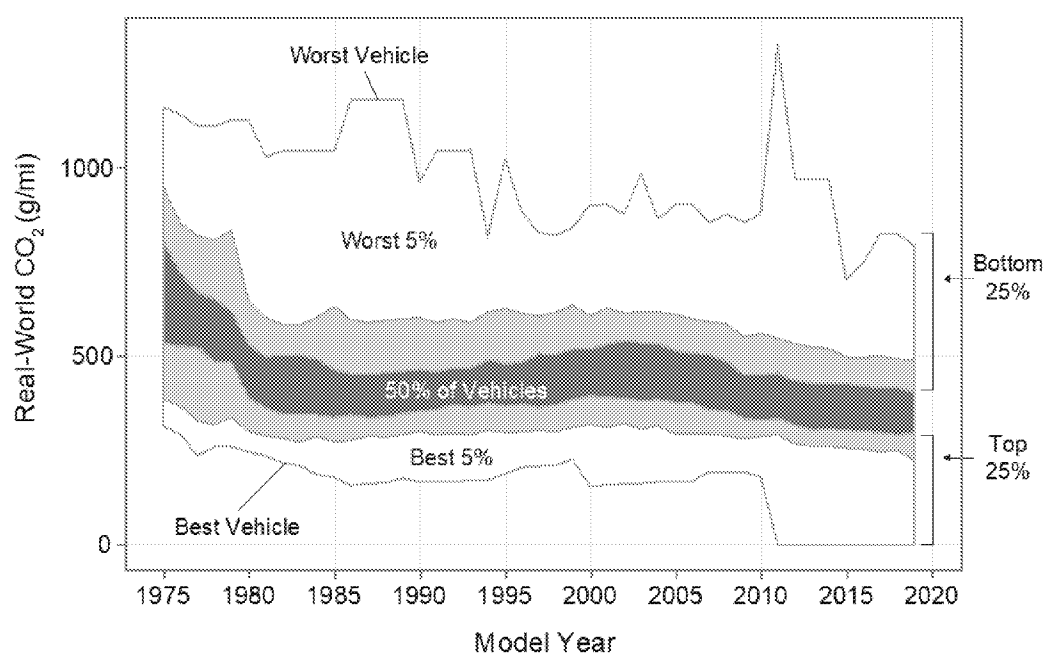
It is important to note that the methodology used in this report for calculating estimated real-world fuel economy and CO_2 emission values has changed over time. For example, the estimated real-world fuel economy for a 1980s vehicle in the Trends database is somewhat higher than it would be if the same vehicle were being produced today as the methodology for calculating these values has changed over time to reflect estimated real-world vehicle operation. These changes are small for most vehicles, but larger for very high fuel economy vehicles. See Appendix C and D for a detailed explanation of fuel economy metrics and their changes over time.

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[4] Electric vehicles prior to 2011 are not included in this figure due to limited data. However, those vehicles were available in small numbers only.

B. Manufacturer Fuel Economy and CO_2 Emissions

Along with the overall industry, most manufacturers have significantly improved new vehicle CO_2 emissions and fuel economy in recent years. Figure 2.4 shows the change in fuel economy and CO_2 emissions from model year 2013 to model year 2018 for the fourteen largest manufacturers. The five-year span covers the approximate length of a vehicle redesign cycle, so it is likely that most vehicles have undergone design changes in this period, resulting in a more accurate depiction of manufacturer trends than focusing on a single year. Over the last five years, twelve of the fourteen largest manufacturers selling vehicles in the U.S. market improved fuel economy, contributing to an overall industry fuel economy increase of 0.9 mpg. Eleven of the fourteen largest manufacturers improved estimated real-world CO_2 emissions, resulting in an overall industry reduction of estimated real-world CO_2 emissions by 15 g/mi.

Tesla, which produces only electric vehicles, had by far the lowest CO_2 emissions, at 0 g/mi, and highest fuel economy, at 113.7 miles per gallon equivalent (mpge)[5], of all large manufacturers in model year 2018.

Of the remaining manufacturers, Honda had the lowest CO_2 emissions and highest fuel economy in model year 2018 and achieved the largest 5-year improvements in CO_2 emissions and fuel economy. Between model years 2013 and 2018, Honda reduced CO_2 emissions by 31 g/mi and increased fuel economy by 2.8 mpg. Subaru and Mazda tied for the third lowest CO_2 emissions and third highest fuel economy in model year 2018. BMW had the second largest 5-year improvement in CO_2 emissions, reducing emissions by 27 g/mi, and Subaru had the third largest improvement, at 26 g/mi. BMW also increased fuel economy by 1.7 mpg, while Subaru increased by 2.2 mpg.

Two manufacturers increased CO_2 emissions and reduced average fuel economy over the five-year span. Volkswagen had the largest increase in CO_2 emissions, at 11 g/mi, and the largest decrease in fuel economy, at 1.3 mpg, due mostly to a large shift towards sport utility vehicles (SUVs). In model year 2018 alone, VW's average new vehicle increased CO_2 emissions by 25 g/mi and reduced fuel economy by 1.8 mpg. Hyundai also increased CO_2 emissions and reduced average fuel economy between model year 2013 and 2018, but to a much smaller degree than VW.

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[5] Miles per gallon of gasoline equivalent (mpge) is an energy-based metric used to compare the energy use of vehicles that operate on fuels other than gasoline to gasoline vehicles. For more information, see Appendix E.

Figure 2.4. Manufacturer Estimated Real-World Fuel Economy and Tailpipe CO_2 in Model Year 2013 and 2018

Fuel Economy (MPG), 2013 – 2018	CO_2 Emissions (g/mi), 2013 – 2018

Tesla — 90.7 → 113.7 | 0
45 — 70 — 95 — 120 | 50 — 100 — 150 — 200

Honda — 27.2 → 30.0 | 296 ← 327
Subaru — 26.5 → 28.7 | 310 ← 336
Mazda — 27.8 → 28.7 | 310 ← 320
Hyundai — 28.6 ◄ 29.0 | 307 ► 311
Kia — 27.2 → 27.8 | 319 ◄ 326
Nissan — 26.5 → 27.1 | 327 ◄ 334
BMW — 24.3 → 26.0 | 339 ← 366
Toyota — 25.0 ► 25.5 | 348 ◄ 355
VW — 24.6 ← 25.9 | 350 → 361
Mercedes — 22.2 → 23.5 | 377 ← 402
GM — 22.0 → 23.0 | 386 ← 403
Ford — 22.2 ► 22.4 | 397 ◄ 400
FCA — 20.9 → 21.7 | 409 ← 426
All Manufacturers — **24.2** → **25.1** | **353** ← **368**

20 — 24 — 28 — 32 | 300 — 350 — 400 — 450

Of the fourteen large manufacturers, FCA had the highest CO_2 emissions and lowest fuel economy in model year 2018. However, FCA did have the largest reduction in CO_2 emission of any large manufacturer between model year 2017 and 2018, with an 11 g/mi reduction, and a corresponding fuel economy increase of 0.6 mpg. After FCA, Ford and GM had the highest new vehicle average CO_2 emissions and lowest fuel economy of the large manufacturers in model year 2018. The manufacturer-specific CO_2 emissions and fuel economy data for the last three model years are shown in Table 2.3.

While each manufacturer has taken a different path towards improving CO_2 emissions and fuel economy, the various technology improvements implemented since 2005 have resulted in steady industry-wide improvement. The vehicle attributes and technologies that have led to this improvement are further analyzed in the next two sections of this report, respectively.

Table 2.1. Production, Estimated Real-World CO_2, and Fuel Economy for Model Year 1975–2019

Model Year	Production (000)	Real-World CO2 (g/mi)	Real-World FE (MPG)	Model Year	Production (000)	Real-World CO2 (g/mi)	Real-World FE (MPG)
1975	10,224	681	13.1	2000	16,571	450	19.8
1976	12,334	625	14.2	2001	15,605	453	19.6
1977	14,123	590	15.1	2002	16,115	457	19.5
1978	14,448	562	15.8	2003	15,773	454	19.6
1979	13,882	560	15.9	2004	15,709	461	19.3
1980	11,306	466	19.2	2005	15,892	447	19.9
1981	10,554	436	20.5	2006	15,104	442	20.1
1982	9,732	425	21.1	2007	15,276	431	20.6
1983	10,302	426	21.0	2008	13,898	424	21.0
1984	14,020	424	21.0	2009	9,316	397	22.4
1985	14,460	417	21.3	2010	11,116	394	22.6
1986	15,365	407	21.8	2011	12,018	399	22.3
1987	14,865	405	22.0	2012	13,449	377	23.6
1988	15,295	407	21.9	2013	15,198	368	24.2
1989	14,453	415	21.4	2014	15,512	369	24.1
1990	12,615	420	21.2	2015	16,739	360	24.6
1991	12,573	418	21.3	2016	16,278	359	24.7
1992	12,172	427	20.8	2017	17,016	357	24.9
1993	13,211	426	20.9	2018	16,259	353	25.1
1994	14,125	436	20.4	2019 (prelim)	--	346	25.5
1995	15,145	434	20.5				
1996	13,144	435	20.4				
1997	14,458	441	20.2				
1998	14,456	442	20.1				
1999	15,215	451	19.7				

To explore this data in more depth, please see the report website at https://www.epa.gov/automotive-trends.

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Table 2.2. Manufactures and Vehicles with the Highest Fuel Economy, by Year

Model Year	Manufacturer with Highest Fuel Economy[6] (mpg)	Manufacturer with Lowest Fuel Economy (mpg)	Overall Vehicle with Highest Fuel Economy[7]			Gasoline (Non-Hybrid) Vehicle with Highest Fuel Economy	
			Vehicle	Real-World FE (mpg)	Engine Type	Gasoline Vehicle	Real-World FE (mpg)
1975	Honda	Ford	Honda Civic	28.3	Gas	Honda Civic	28.3
1980	VW	Ford	VW Rabbit	40.3	Diesel	Nissan 210	36.1
1985	Honda	Mercedes	GM Sprint	49.6	Gas	GM Sprint	49.6
1990	Hyundai	Mercedes	GM Metro	53.4	Gas	GM Metro	53.4
1995	Honda	FCA	Honda Civic	47.3	Gas	Honda Civic	47.3
2000	Hyundai	FCA	Honda Insight	57.4	Hybrid	GM Metro	39.4
2005	Honda	Ford	Honda Insight	53.3	Hybrid	Honda Civic	35.1
2006	Mazda	Ford	Honda Insight	53.0	Hybrid	Toyota Corolla	32.3
2007	Toyota	Mercedes	Toyota Prius	46.2	Hybrid	Toyota Yaris	32.6
2008	Hyundai	Mercedes	Toyota Prius	46.2	Hybrid	Smart Fortwo	37.1
2009	Toyota	FCA	Toyota Prius	46.2	Hybrid	Smart Fortwo	37.1
2010	Hyundai	Mercedes	Honda FCX	60.2	FCV	Smart Fortwo	36.8
2011	Hyundai	Mercedes	BMW Active E	100.6	EV	Smart Fortwo	35.7
2012	Hyundai	FCA	Nissan-i-MiEV	109.0	EV	Toyota iQ	36.8
2013	Hyundai	FCA	Toyota IQ	117.0	EV	Toyota iQ	36.8
2014	Mazda	FCA	BMW i3	121.3	EV	Mitsubishi Mirage	39.5
2015	Mazda	FCA	BMW i3	121.3	EV	Mitsubishi Mirage	39.5
2016	Mazda	FCA	BMW i3	121.3	EV	Mazda 2	37.1
2017	Honda	FCA	Hyundai Ioniq	132.6	EV	Mitsubishi Mirage	41.5
2018	Tesla	FCA	Hyundai Ioniq	132.6	EV	Mitsubishi Mirage	41.5
2019 (prelim)	*Tesla*	*FCA*	*Hyundai Ioniq*	*132.6*	*EV*	*Mitsubishi Mirage*	*40.1*

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[6] Manufacturers below the 150,000 threshold for "large" manufacturers are excluded in years they did not meet the threshold.

[7] Vehicles are shown based on estimated real-world fuel economy as calculated for this report. These values will differ from values found on the fuel economy labels at the time of sale. For more information on fuel economy metrics see Appendix C.

Table 2.3. Manufacturer Estimated Real-World Fuel Economy and CO_2 Emissions for Model Year 2017–2019

Manufacturer	MY 2017 Final		MY 2018 Final				MY 2019 Preliminary	
	Real-World FE (mpg)	Real-World CO_2 (g/mi)	Real-World FE (mpg)	FE Change from MY 2017 (mpg)	Real-World CO_2 (g/mi)	CO_2 Change from MY 2017 (g/mi)	Real-World FE (mpg)	Real-World CO_2 (g/mi)
BMW	25.8	342	26.0	0.2	339	-3	26.0	340
FCA	21.1	420	21.7	0.6	409	-11	22.3	398
Ford	22.9	388	22.4	-0.4	397	8	22.8	390
GM	22.8	388	23.0	0.2	386	-2	22.8	389
Honda	29.4	302	30.0	0.6	296	-6	28.8	308
Hyundai	28.6	311	28.6	0.0	311	0	27.3	324
Kia	27.1	327	27.8	0.6	319	-8	27.6	321
Mazda	29.0	306	28.7	-0.4	310	4	27.8	322
Mercedes	23.0	385	23.5	0.5	377	-8	24.4	363
Nissan	26.9	330	27.1	0.2	327	-3	26.9	328
Subaru	28.5	312	28.7	0.2	310	-2	28.1	317
Tesla	98.2	0	113.7	15.5	0	0	117.7	0
Toyota	25.3	351	25.5	0.2	348	-3	26.1	341
VW	26.4	336	24.6	-1.8	361	25	26.4	336
All Manufacturers	**24.9**	**357**	**25.1**	**0.2**	**353**	**-4**	**25.5**	**346**

To explore this data in more depth, please see the report website at https://www.epa.gov/automotive-trends.

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3. Vehicle Attributes

Vehicle CO_2 emissions and fuel economy are strongly influenced by vehicle design parameters, including weight, power, acceleration, and size. In general, vehicles that are larger, heavier, and more powerful typically have lower fuel economy and higher CO_2 emissions than other comparable vehicles. This section focuses on several key vehicle design attributes that impact CO_2 emissions and fuel economy and evaluates the impact of a changing automotive marketplace on overall fuel economy.

A. Vehicle Class and Type

Manufacturers offer a wide variety of light-duty vehicles in the United States. Under the CAFE and GHG regulations, new vehicles are separated into two distinct regulatory classes, cars and trucks, and each vehicle class has separate GHG and fuel economy standards. Vehicles that weigh more than 6,000 pounds gross vehicle weight[8] (GVW) or have four-wheel drive and meet various off-road requirements, such as ground clearance, qualify as trucks. Vehicles that do not meet these requirements are considered cars.

Pickup trucks, vans, and minivans are all considered trucks under the regulatory definitions, while sedans, coupes, and wagons are generally classified as cars. Sport utility vehicles (SUVs), fall into both categories. Based on the CAFE and GHG regulatory definitions, all two-wheel drive SUVs under 6,000 pounds GVW are classified as cars, while most SUVs that have four-wheel drive or are above 6,000 pounds GVW are considered trucks. SUV models that are less than 6,000 pounds GVW can have both car and truck variants, with two-wheel drive versions classified as cars and four-wheel drive versions classified as trucks. As the fleet has changed over time, the line drawn between car and truck classes has also evolved. This report uses the current regulatory car and truck definitions, and these changes have been propagated back throughout the historical data.

This report further separates the car and truck regulatory classes into five vehicle type categories based on their body style classifications under the fuel economy labeling program. The regulatory car class is divided into two vehicle types: sedan/wagon and car SUV. The sedan/wagon vehicle type includes minicompact, subcompact, compact, midsize, large, and two-seater cars, hatchbacks, and station wagons. Vehicles that are SUVs under the labeling program and cars under the CAFE and GHG regulations are classified as car

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[8] Gross vehicle weight is the combined weight of the vehicle, passengers, and cargo of a fully loaded vehicle.

SUVs in this report. The truck class is divided into three vehicle types: pickup, minivan/van, and truck SUV. Vehicles that are SUVs under the labeling program and trucks under the CAFE and GHG regulations are classified as truck SUVs. Figure 3.1 shows the two regulatory classes and five vehicle types used in this report. The distinction between these five vehicle types is important because different vehicle types have different design objectives, and different challenges and opportunities for improving fuel economy and reducing CO_2 emissions.

Figure 3.1. Regulatory Classes and Vehicle Types Used in This Report
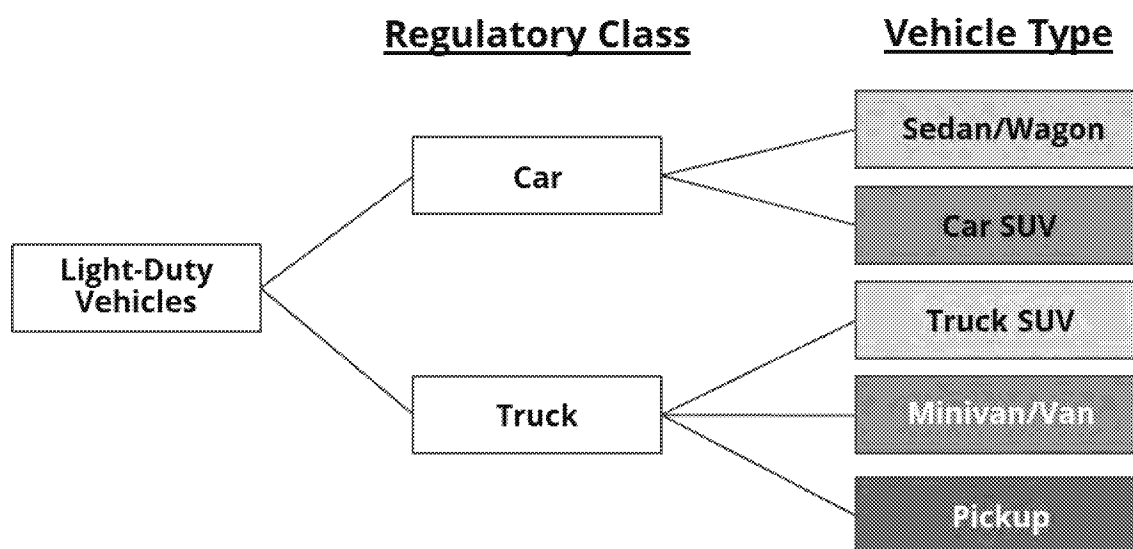
Fuel Economy and CO_2 by Vehicle Type

The production volume of the different vehicle types has changed significantly over time. Figure 3.2 shows the production shares of each of the five vehicle types for model years 1975-2018. Sedans/wagons were the dominant vehicle type in 1975, when more than 80% of vehicles produced were sedans/wagons. Since then, their production share has generally been falling, and by model year 2018 sedans/wagons captured a record low 37% of the market, or less than half of the market share they held in model year 1975. The production share of pickups has remained relatively consistent, fluctuating from 13% in model year 1975 to 14% in model year 2018. Minivan/vans captured less than 5% of the market in 1975, increased to 11% in model year 1995 but have fallen since to 3% of vehicle production. Vehicles that could be classified as a car SUV or truck SUV were a very small part of the production share in 1975 but have shown sustained growth since. By model year 2018, truck SUVs reached a record high 35% of production, and car SUVs remained near a record high, falling very slightly to 11% of production.

In model year 2018, 48% of the fleet were cars and 52% were trucks. This was the highest percentage of trucks on record and a significant change from 1975. In Figure 3.2, the dashed line between the car SUVs and truck SUVs shows the split in car and truck regulatory class.

Figure 3.2. Production Share and Estimated Real-World Fuel Economy
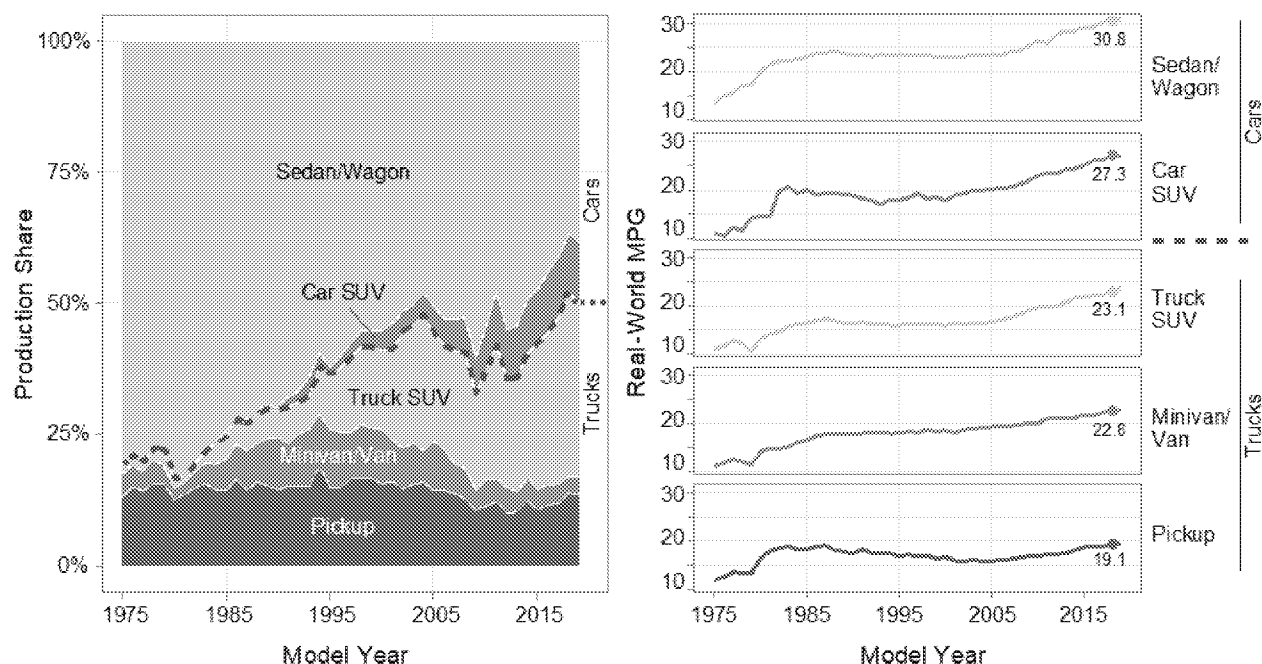
Figure 3.2 also shows estimated real-world fuel economy for each vehicle type since 1975. Fuel economy has improved for each of the five vehicle types for several years, and all are at record fuel economy and CO_2 emissions levels in model year 2018. Car SUVs had the largest year-over-year improvements in model year 2018, improving 1.2 mpg to 27.3 mpg. Truck SUVs had the second largest improvement, increasing 0.8 mpg to 23.1 mpg. Sedans/wagons increased 0.6 mpg in model year 2018 to 30.8 mpg, minivans/vans increased 0.5 mpg to 22.8 mpg, and pickups increased 0.2 mpg to 19.1 mpg. The small increase for pickup trucks pushed pickup fuel economy above the previous record for pickups, which was set in 1987. All the vehicle types, except for pickups, now achieve fuel economy more than double what they achieved in 1975. In the preliminary model year 2019 data, truck SUVs and pickups are expected to further improve fuel economy, while car SUVs are projected to decrease, and sedan/wagons and minivan/vans are projected to remain at about the same fuel economy.

While each of the five vehicle types increased between 0.2 and 1.2 mpg, overall fuel economy improved only 0.2 mpg in model year 2018. The market shift towards SUVs and

away from sedan/wagons has offset some of the fleetwide benefits that otherwise would have been achieved from the increased fuel economy within each vehicle type.

Vehicle Type by Manufacturer

The model year 2018 production breakdown by vehicle type for each manufacturer is shown in Figure 3.3. There are clear variations in production distribution by manufacturer. Almost 90% of Tesla's production was sedans/wagons, which is the highest of any manufacturer. For other vehicle types, Hyundai had the highest percentage of car SUVs at 37%, Subaru had the highest percentage of truck SUVs at 78%, Ford had the highest percentage of pickups at 34%, and FCA had the highest percentage of minivan/vans at 13%.

Most manufacturers reported a reduction in the percentage of sedan/wagons produced in model year 2018, compared to the previous year. The manufacturer with the largest change was VW, which reduced the percentage of sedan/wagons produced from 72% to 45% in one model year. VW's truck SUV production increased from 25% to 55%, as VW introduced new SUV models.

Figure 3.3. Vehicle Type Distribution by Manufacturer for Model Year 2018
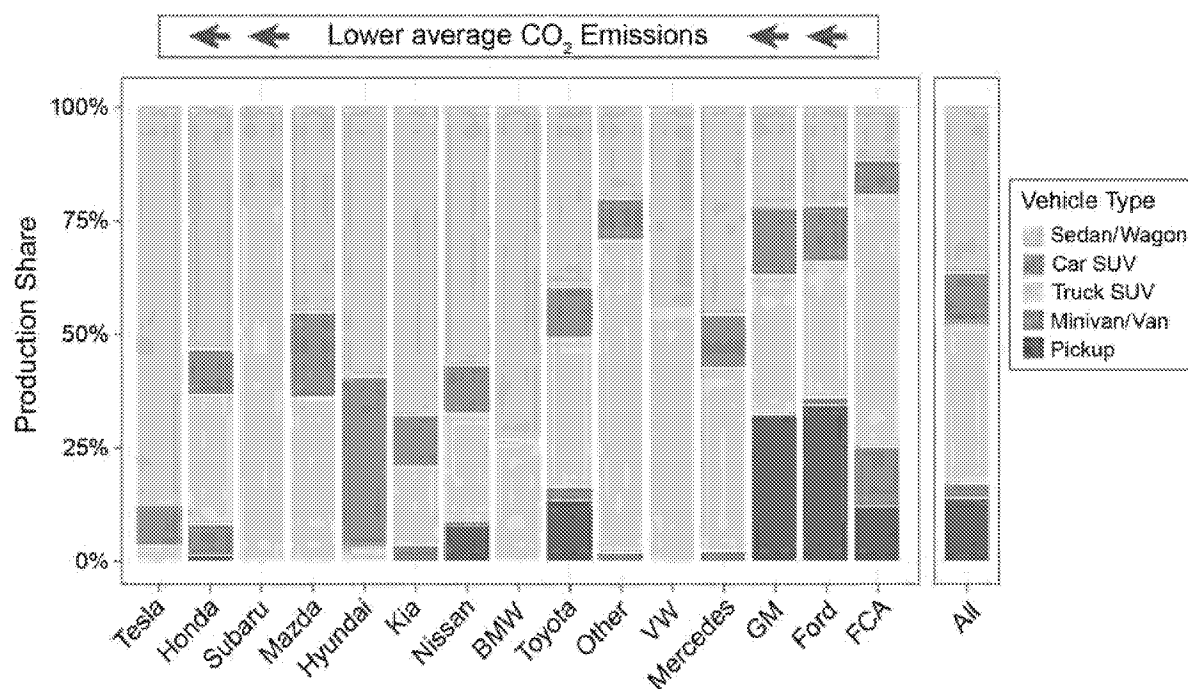
SUV Classification

Over the last 30 years, the production share of SUVs in the United States has increased in all but six years and now accounts for more than 45% of all vehicles produced (see Figure 3.2). This includes both the car and truck SUV vehicle types.

Based on the regulatory definitions of cars and trucks, SUVs that are less than 6,000 pounds GVW can be classified as either cars or trucks, depending on design requirements such as minimum angles and clearances, and whether the vehicle has 2-wheel drive or 4-wheel drive. This definition can lead to similar vehicles having different car or truck classifications, and different requirements under the GHG and CAFE regulations. One particular trend of interest is the classification of SUVs as either car SUVs or truck SUVs.

This report does not track GVW, but instead tracks weight using inertia weight classes, where inertia weight is the weight of the empty vehicle, plus 300 pounds (see weight discussion on the next page). Figure 3.4 shows the breakdown of SUVs into the car and truck categories over time for vehicles with an inertia weight of 4,000 pounds or less. Vehicles in the 4,500-pound inertia weight class and higher were excluded, as these vehicles generally exceed 6,000 pounds GVW and are classified as trucks. The relative percentage of SUVs with an inertia weight of 4,000 pounds or less that meet the current regulatory truck definition has stayed relatively constant over time, suggesting that there has not been a shift in vehicle design to make these vehicles fall into the car or truck regulatory category.

Figure 3.4. Car-Truck Classification of SUVs with Inertia Weights of 4000 Pounds or Less

ED_006488A_00003717-00024
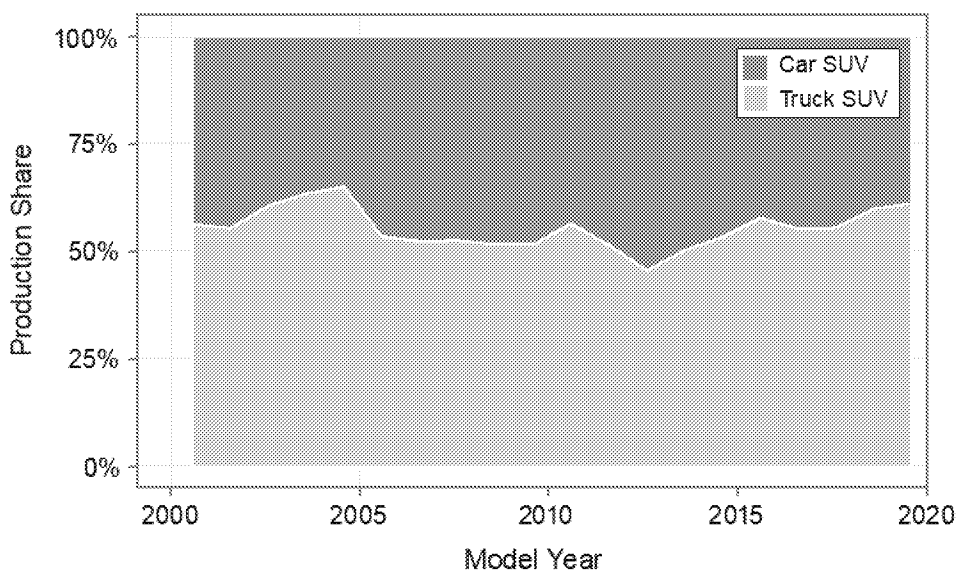
B. Vehicle Weight

Vehicle weight is a fundamental vehicle attribute, both because it can be related to utility functions such as vehicle size and features, and because higher weight, other things being equal, will increase CO_2 emissions and decrease fuel economy. All vehicle weight data in this report are based on inertia weight classes. Each inertia weight class represents a range of loaded vehicle weights, or vehicle curb weights[9] plus 300 pounds. Vehicle inertia weight classes are in 250-pound increments for classes below 3,000 pounds, while inertia weight classes over 3,000 pounds are divided into 500-pound increments.

Vehicle Weight by Vehicle Type

Figure 3.5 shows the average new vehicle weight from model year 1975 through 2019[10] for all new vehicles by vehicle type. From model year 1975 to 1981, average vehicle weight dropped 21%, from 4,060 pounds per vehicle to about 3,200 pounds; this was likely driven by both increasing fuel economy standards (which, at the time, were universal standards, and not based on any type of vehicle attribute) and higher gasoline prices.

From model year 1981 to model year 2004, the trend reversed, and average new vehicle weight began to slowly but steadily climb. By model year 2004, average new vehicle weight had increased 28% and reached 4,111 pounds per vehicle, in part because of the increasing truck share. Since model year 2004, new vehicle weight has been relatively flat even as truck share has continued to increase. Average vehicle weight did reach a new high in model year 2018 at 4,137 pounds, but it was less than 1% higher than model year 2004 and preliminary model year 2019 data suggest that weight will decrease.

In model year 1975, the average new sedan/wagon outweighed the average new pickup by about 45 pounds. The average weight of each of the five vehicle types varied by only about 215 pounds, or about 5% of the average new vehicle. However, by model year 2018 the difference between the lightest vehicle type, sedan/wagons, and the heaviest, pickups, increased to almost 1,700 pounds, or more than 40% of the average new vehicle weight. The weight of an average new sedan/wagon fell 13% between model year 1975 and 2018, while the weight of an average new pickup increased 30%. The large drop in weight for pickups in model year 2015 is correlated with the redesign of the Ford F-150 to a largely aluminum body.

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[9] Vehicle curb weight is the weight of an empty, unloaded vehicle.
[10] Model year 2019 data is shown as a separate dot, due to the uncertainty in this projected data.

Figure 3.5. Average New Vehicle Weight by Vehicle Type
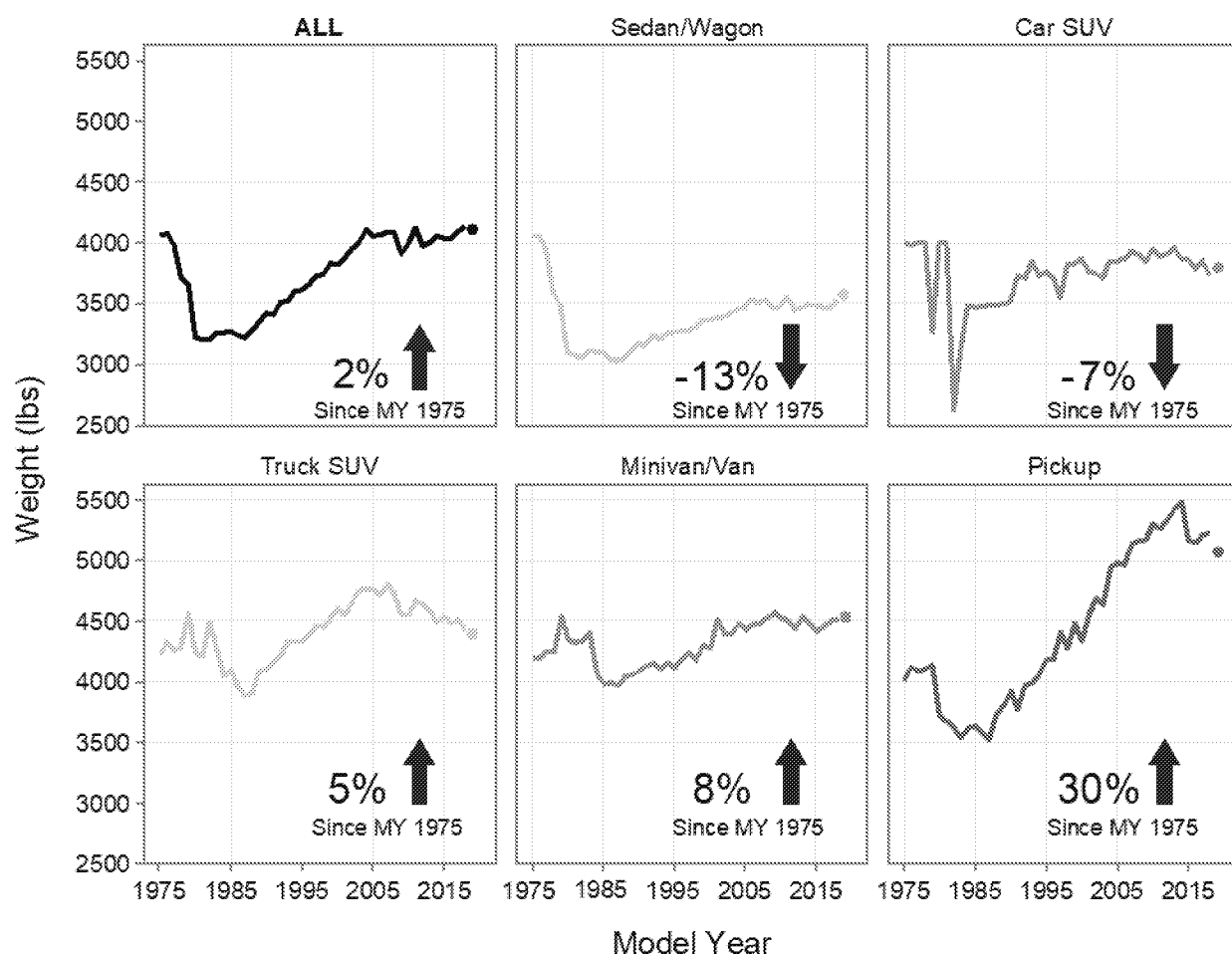
Figure 3.6 shows the annual production share of different inertia weight classes for new vehicles since model year 1975. In model year 1975 there were significant sales in all weight classes from <2,750 pounds to 5,500 pounds. In the early 1980s the largest vehicles disappeared from the market, and light cars <2,750 pounds inertia weight briefly captured more than 25% of the market. Since then, cars in the <2,750-pound inertia weight class have all but disappeared, and the market has moved towards heavier vehicles. Interestingly, the heaviest vehicles in model year 1975 were mostly large cars in the 5,500-pound inertia weight class, whereas the heaviest vehicles today are all trucks.

Figure 3.6. Inertia Weight Class Distribution by Model Year
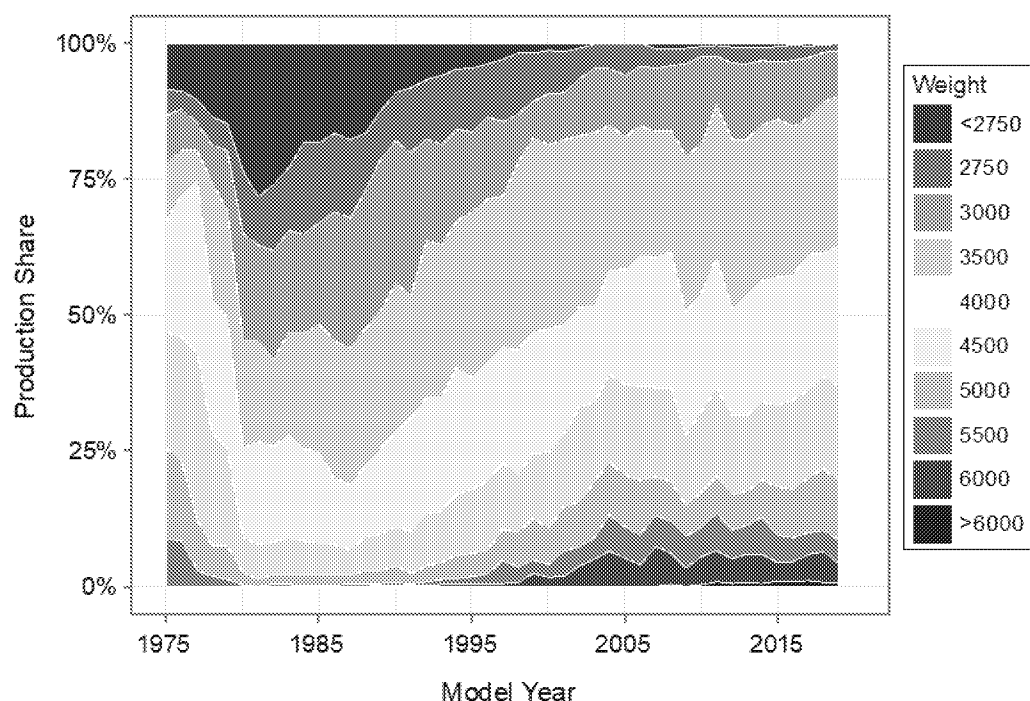
Vehicle Weight and CO_2 Emissions

Heavier vehicles require more energy to move than lower-weight vehicles and, if all other factors are the same, will have lower fuel economy and higher CO_2 emissions. The wide array of technology available in modern vehicles complicates this comparison, but it is still useful to evaluate the relationship between vehicle weight and CO_2 emissions, and how these variables have changed over time.

Figure 3.7 shows estimated real-world CO_2 emissions as a function of vehicle inertia weight for model year 1978[11] and model year 2019. On average, CO_2 emissions increase linearly with vehicle weight for both model years, although the rate of change as vehicles get heavier is different between model year 2019 and 1978. At lower weights, vehicles from model year 2019 produce about two thirds of the CO_2 emissions of 1978 vehicles. The difference between model year 2018 and 1978 increases for heavier vehicles, as the heaviest model year 2019 vehicles produce about half of the CO_2 emissions of 1978 vehicles. Electric vehicles, which do not produce any tailpipe CO_2 emissions regardless of

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[11] Model year 1978 was the first year for which complete horsepower data are available, therefore it will be used for several historical comparisons for consistency.

weight, are visible along the 0 g/mi axis of Figure 3.7. As more electric vehicles are introduced into the market, the relationship between average vehicle CO_2 emissions and inertia weight will continue to evolve.

Figure 3.7. Relationship of Inertia Weight and CO_2 Emissions
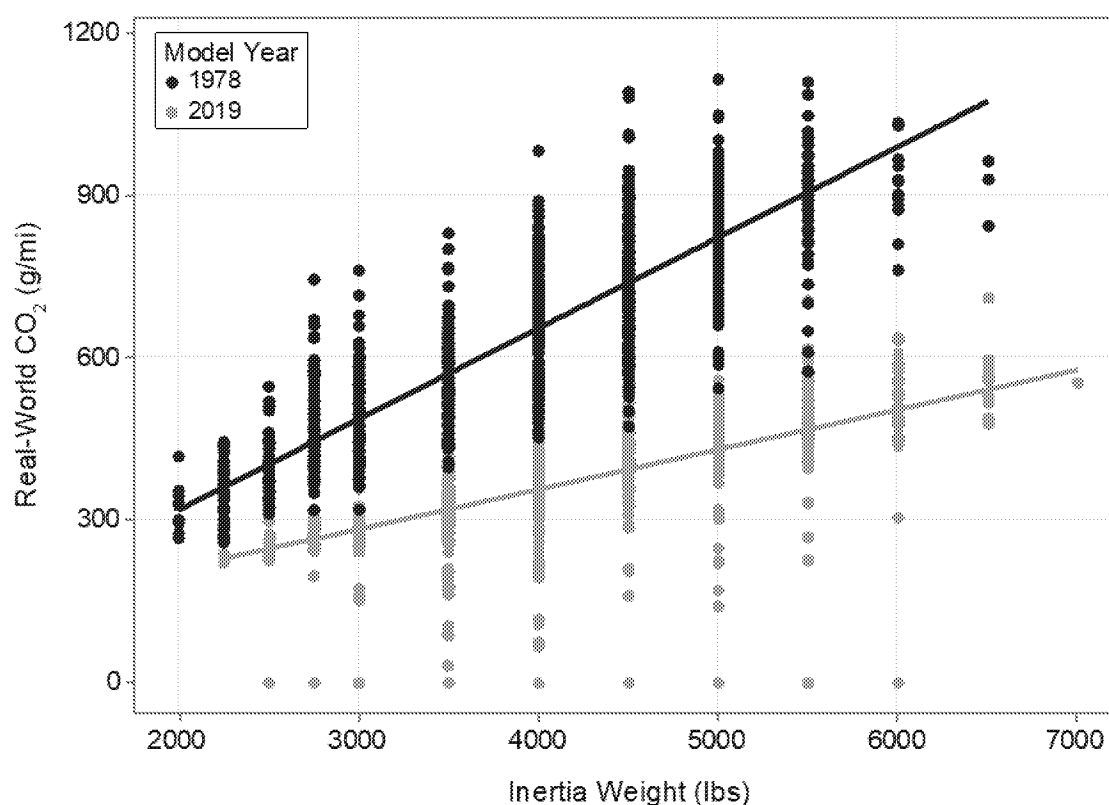
C. Vehicle Power

Vehicle power, measured in horsepower (hp), has changed dramatically since model year 1975. The average new vehicle in model year 2018 produced 75% more power than a new vehicle in model year 1975, and almost 136% more power than an average new vehicle in model year 1981. In the early years of this report, horsepower fell, from an average of 137 hp in model year 1975 to 102 hp in model year 1981. Since model year 1981, however, horsepower has increased 32 out of 37 years. The average new vehicle horsepower is at a record high, increasing from 234 hp in model year 2017 to 241 hp in model year 2018. The preliminary value for model year 2019 is 244 hp, which would be another record-high for horsepower.

Vehicle Power by Vehicle Type

As with weight, the changes in horsepower are also quite different among vehicle types. Horsepower for sedan/wagons increased 50% between model year 1975 and 2018, almost 70% for car SUVs and truck SUVs, almost 90% for minivan/vans, and 145% for pickups. Increases in horsepower have been more variable over the last decade, but the general trend continues to be increasing horsepower. The projected model year 2019 data shows another expected increase of about 4 hp.

Figure 3.8. Average New Vehicle Horsepower by Vehicle Type
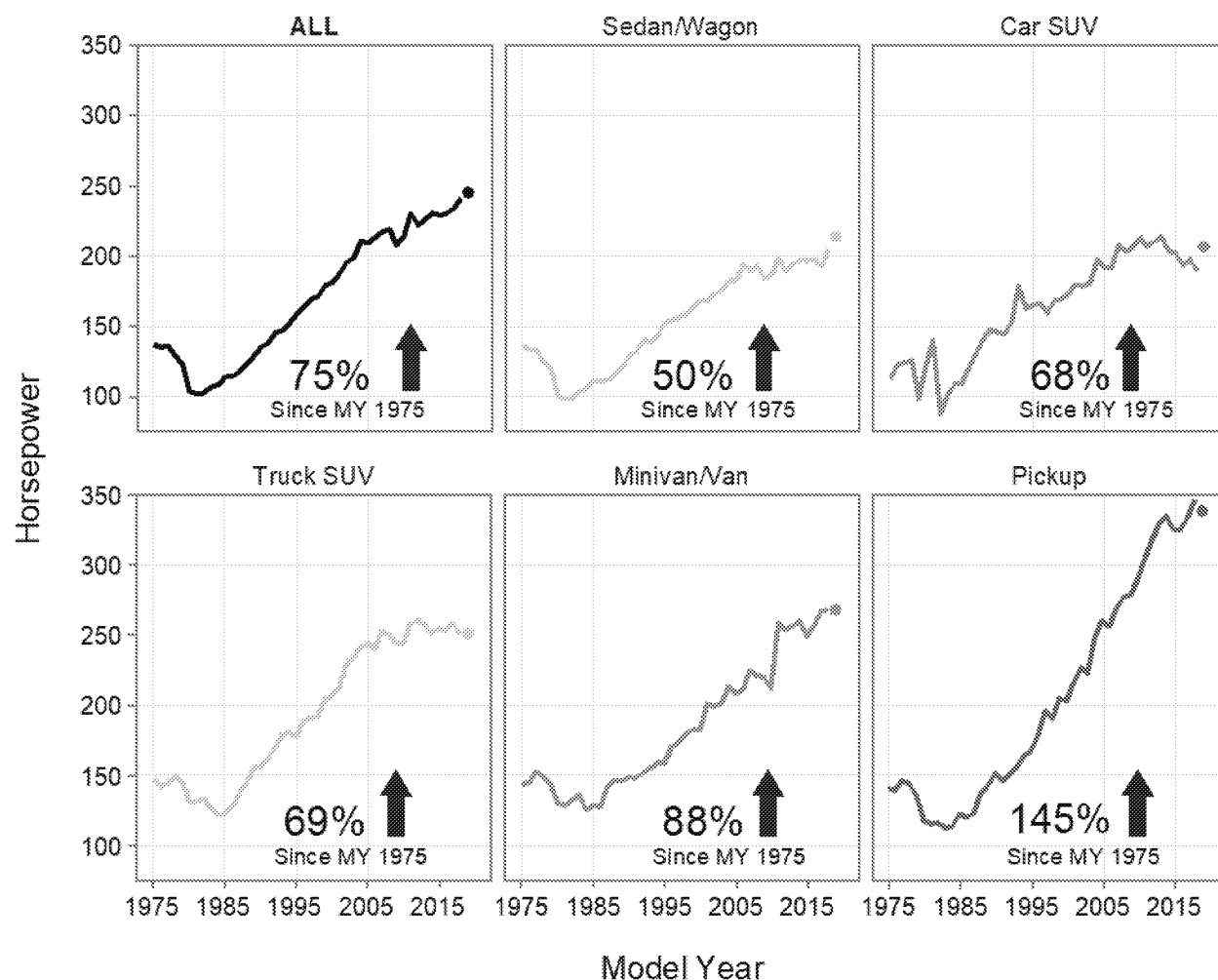
The distribution of horsepower over time has shifted significantly towards vehicles with more horsepower, as show in Figure 3.9. In the early 1980s, more than half of all new vehicles had 100 to 150 hp, and very few had more than 200 hp. The average model year 2019 vehicle is projected to have more than 240 hp, and very few vehicles have less than 150 hp. Vehicles with more than 300 hp are projected to make up more than 45% of new vehicle production, and vehicles with more than 350 hp are projected to make up more than 20% of new vehicle production. The maximum horsepower for an individual vehicle is now well over 1,000 hp.

Figure 3.9. Horsepower Distribution by Model Year
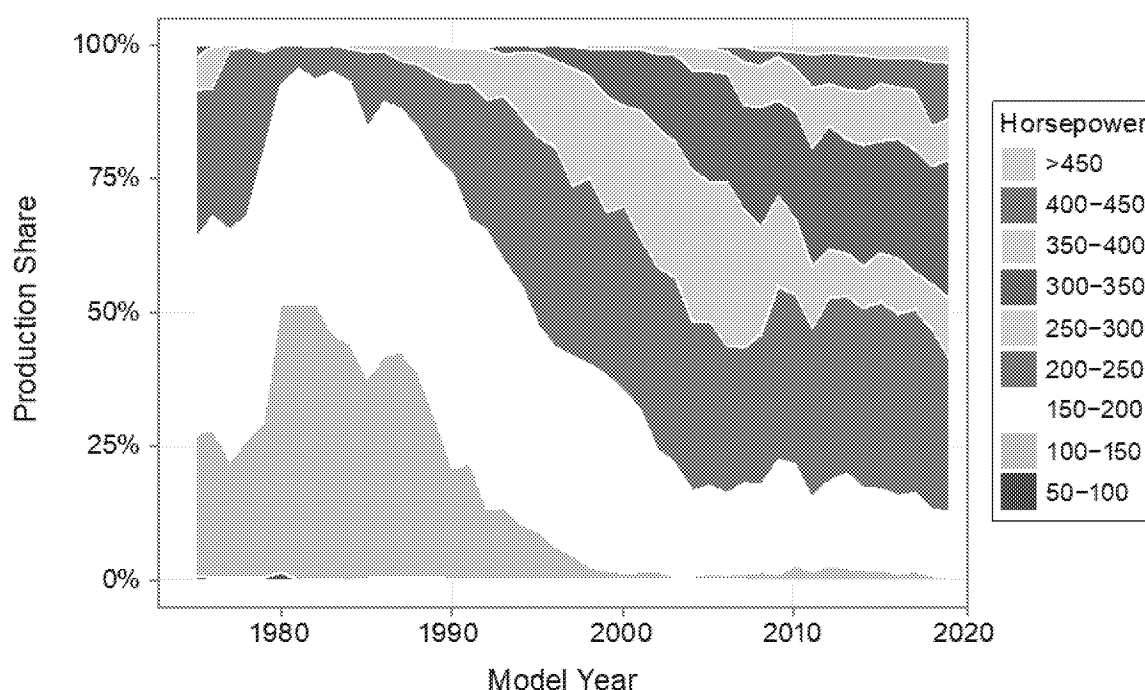
Vehicle Power and CO_2 Emissions

The relationship between vehicle power, CO_2 emissions, and fuel economy has become more complex as new technology and vehicles have emerged in the marketplace. In the past, higher power generally increased CO_2 emissions and decreased fuel economy, especially when new vehicle production relied exclusively on gasoline and diesel internal combustion engines. As shown in Figure 3.10, model year 1978 vehicles with increased horsepower generally had increased CO_2 emissions. In model year 2019, CO_2 emissions increase with increased vehicle horsepower at a much lower rate than in model year 1978,

such that model year 2019 vehicles nearly all have lower CO_2 emissions than their model year 1978 counterparts with the same amount of power. Technology improvements, including turbocharged engines and hybrid packages, have reduced the incremental CO_2 emissions associated with increased power. Electric vehicles are present along the 0 g/mi line in Figure 3.10 because they produce no tailpipe CO_2 emissions, regardless of horsepower, further complicating this analysis for modern vehicles.

Figure 3.10. Relationship of Horsepower and CO_2 Emissions
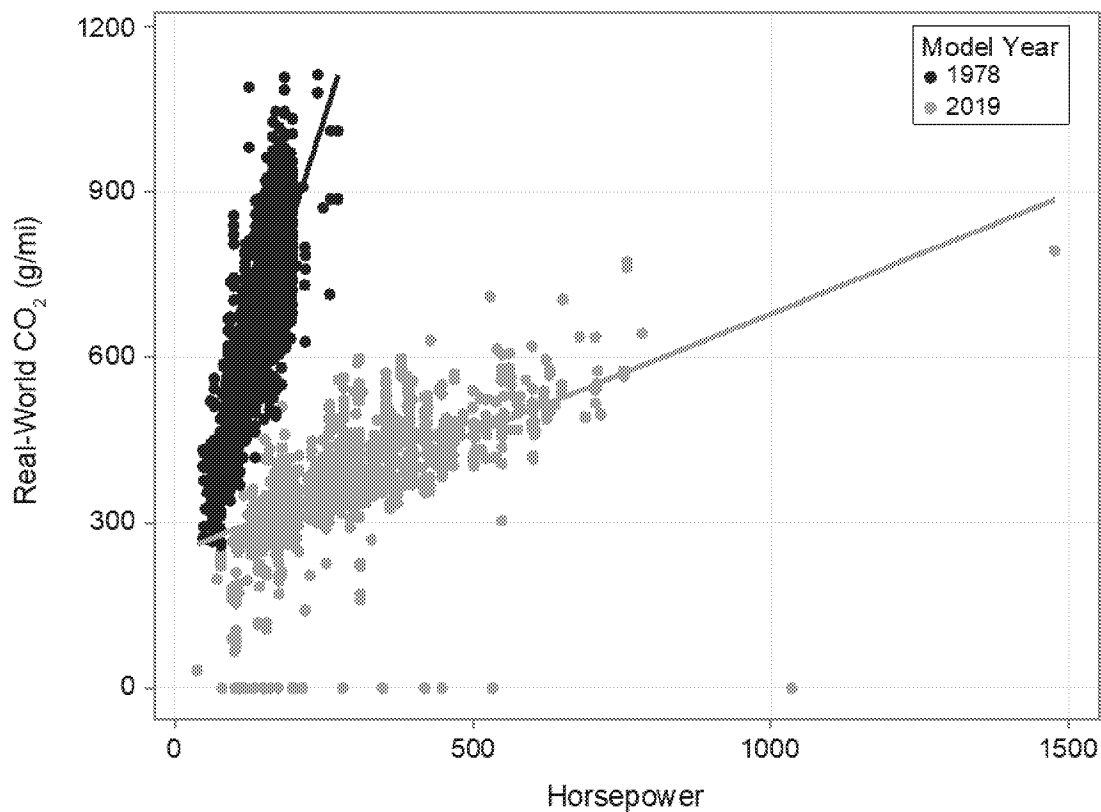
Vehicle Acceleration

Vehicle acceleration is closely related to vehicle horsepower. As new vehicles have increased horsepower, the corresponding ability of vehicles to accelerate has also increased. The most common vehicle acceleration metric, and one of the most recognized vehicle metrics overall, is the time it takes a vehicle to accelerate from 0 to 60 miles per hour, also called the 0-to-60 time. Data on 0-to-60 times are not directly submitted to EPA but are calculated for most vehicles using vehicle attributes and calculation methods

developed by MacKenzie and Heywood (2012).[12] Data are obtained from external sources for hybrids and electric vehicles.

Since the early 1980s, there has been a clear downward trend in 0-to-60 times. Figure 3.11 shows the average new vehicle 0-to-60 time from model year 1978 to model year 2018. The average new vehicle in model year 2018 has a 0-to-60 time of 8.0 seconds, which is the fastest average 0-to-60 time since the database began in 1975 and is approaching half of the average 0-to-60 times of the early 1980s. The calculated 0-to-60 time for model year 2019 is projected to fall further, to 7.8 seconds.

Figure 3.11. Calculated 0-to-60 Time by Vehicle Type

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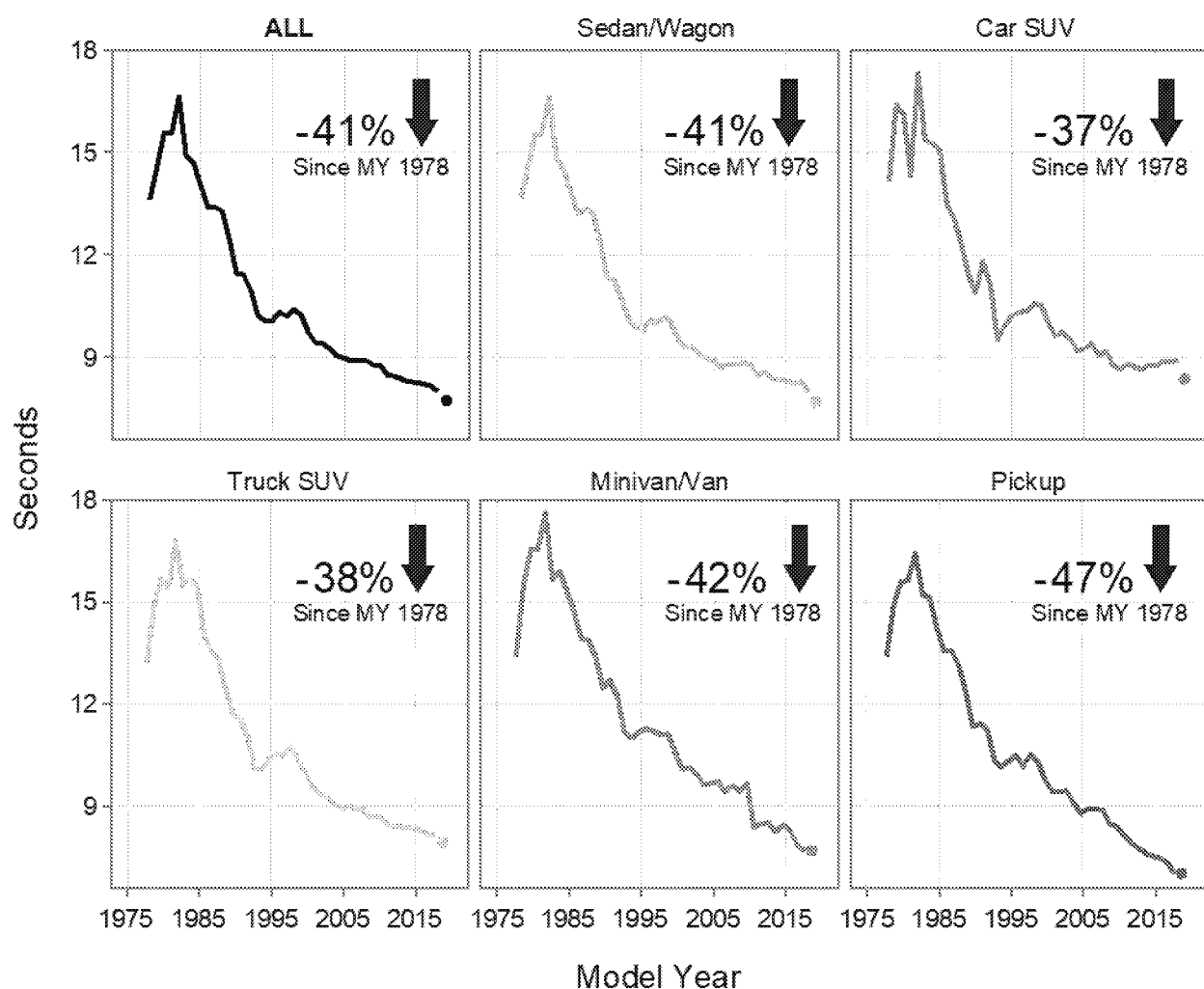
[12] MacKenzie, D. Heywood, J. 2012. Acceleration performance trends and the evolving relationship among power, weight, and acceleration in U.S. light-duty vehicles: A linear regression analysis. Transportation Research Board, Paper NO 12-1475, TRB 91st Annual Meeting, Washington, DC, January 2012.

The long-term downward trend in 0-to-60 times is consistent across all vehicle types, though it appears to be diverging in more recent years. The average 0-to-60 time for pickups continues to decrease steadily, while times for car SUVs have begun to flatten out. The continuing decrease in pickup truck 0-to-60 times is likely due to their increasing power, as shown in Figure 3.8. While much of that power is intended to increase towing and hauling capacity, it also decreases 0-to-60 times.

D. Vehicle Footprint

Vehicle footprint is a very important attribute since it is the basis for the current CO_2 emissions and fuel economy standards. Footprint is the product of wheelbase times average track width (the area defined by where the centers of the tires touch the ground). This report provides footprint data beginning with model year 2008, although footprint data from model years 2008–2010 were aggregated from various sources and EPA has less confidence in the precision of these data than that of formal compliance data. Beginning in model year 2011, the first year when both car and truck CAFE standards were based on footprint, automakers began to submit reports to EPA with footprint data at the end of the model year, and these official footprint data are reflected in the final data through model year 2018. EPA projects footprint data for the preliminary model year 2019 fleet based on footprint values from the previous model year and, for new vehicle designs, publicly available data.

Vehicle Footprint by Vehicle Type

Figure 3.12 shows overall new vehicle and vehicle type footprint data since model year 2008. Between model year 2008 and 2018, the overall average footprint increased 3.1%, from 48.9 to 50.4 square feet. The overall average is influenced by the trends within each vehicle type, as well as the mix of new vehicles produced and the market shift toward larger vehicles. Within each of the five vehicle types, footprint increased for all vehicle types except for car SUVs between model year 2008 and 2018. Car SUVs decreased 0.3 square feet (0.6%), truck SUVs increased 0.4 square feet (0.8%), sedan/wagons increased 1.5 square feet (3.3%), minivan/vans increased 1.4 square feet (2.5%), and pickups increased 2.5 square feet (4.0%). The distribution of footprints across all new vehicles, as shown in Figure 3.13, also shows only slight changes over time with approximately two-thirds of all vehicles in the 40–50 square feet range. Projected data for model year 2019 show overall footprint will decrease slightly to an average of 50.2 square feet.

Figure 3.12. Footprint by Vehicle Type for Model Year 2008–2019
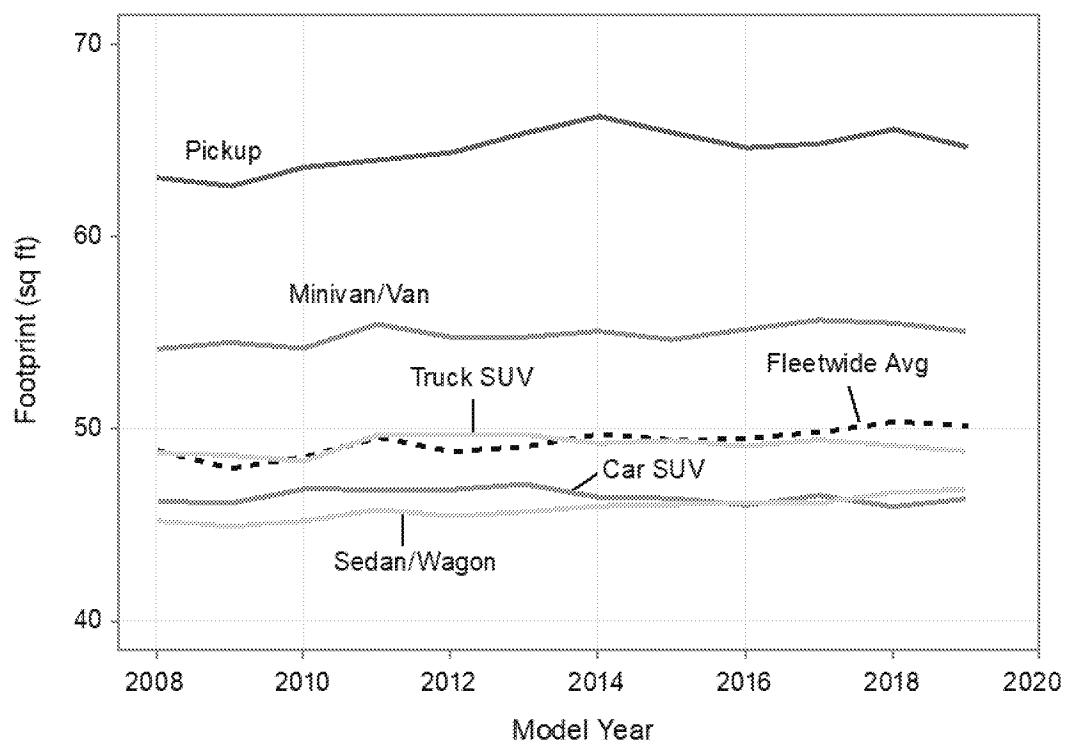
Figure 3.13. Footprint Distribution by Model Year
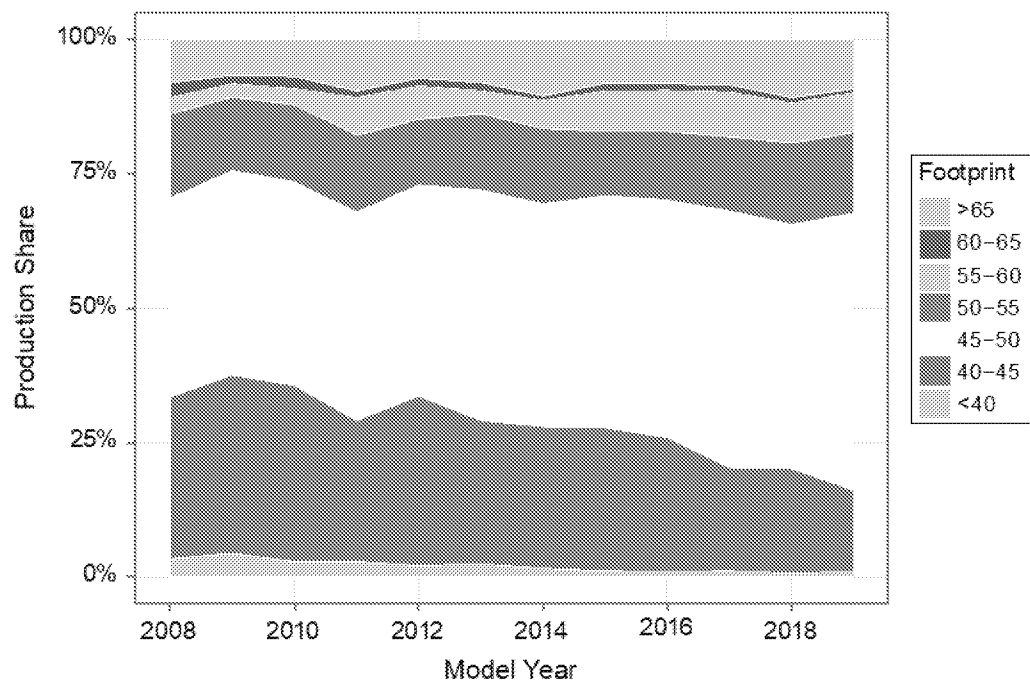
Vehicle Footprint and CO_2 Emissions

The relationship between vehicle footprint and CO_2 emissions is shown in Figure 3.14. Vehicles with a larger footprint are likely to weigh more and have more frontal area, which leads to increased aerodynamic resistance. Increased weight and aerodynamic resistance increase CO_2 emissions and decreases fuel economy. The general trend of increasing footprint and CO_2 emissions holds true for vehicles from model year 2008 and model year 2019, although vehicles produced in model year 2019 produce roughly 20% less CO_2 emissions than model year 2008 vehicles of a comparable footprint. Electric vehicles are shown in Figure 3.14 with zero tailpipe CO_2 emissions, regardless of footprint. As more electric vehicles enter the market, the relationship between footprint and tailpipe CO_2 emissions will become much flatter, or less sensitive to footprint.

Figure 3.14. Relationship of Footprint and CO_2 Emissions
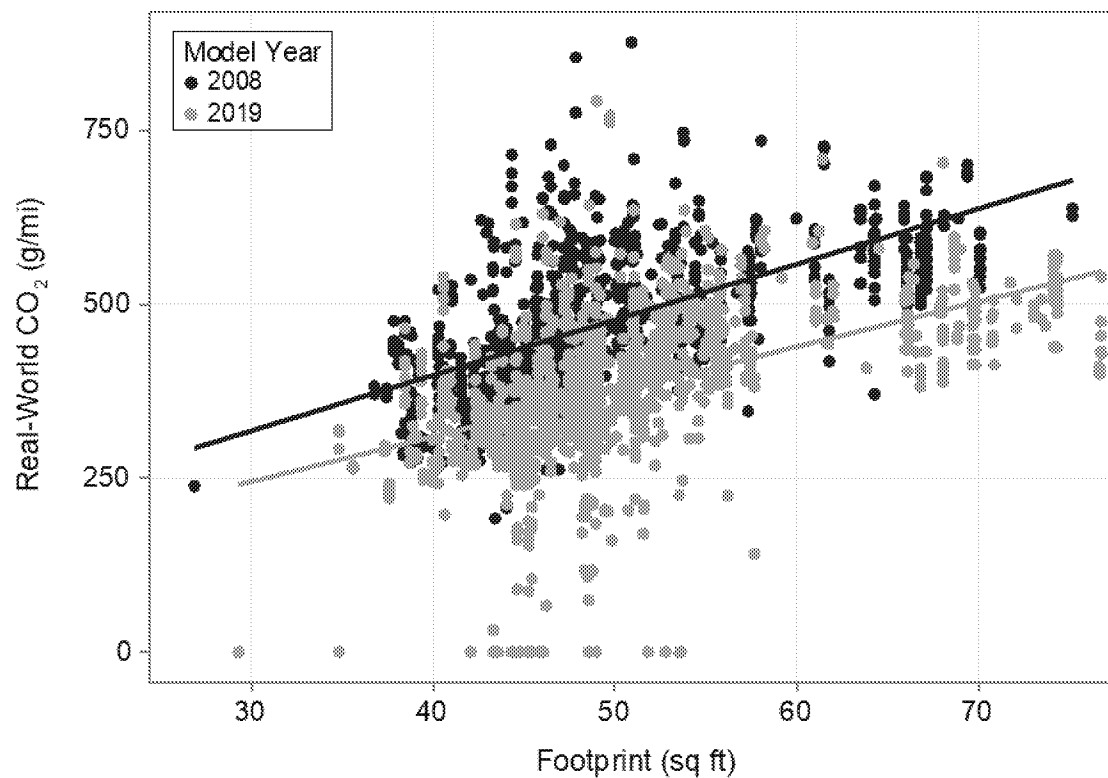
E. Summary

The past 40+ years of data show striking changes in the attributes of vehicles produced for sale in the United States. The marketplace has moved from more than 80% cars to a much more varied mix of vehicles, with recent growth in SUV sales (car SUVs and truck SUVs) resulting in SUVs capturing more than 40% of the market. The weight of an average new vehicle fell dramatically in the late 1970s, then slowly climbed for about 20 years before flattening off. In 2018 sedans/wagons have an average weight that is 13% below 1975, but pickups are now about 30% heavier than in model year 1975. Vehicle power and acceleration have increased across all vehicle types, with average horsepower more than doubling the lows reached in the early 1980s. Vehicle footprint has increased about 3% since this report began tracking the data in model year 2008. Figure 3.15 shows a summary of the relative changes in fuel economy, weight, horsepower, and fuel economy since 1975.

Figure 3.15. Relative Change in Fuel Economy, Weight, and Horsepower, since Model Year 1975
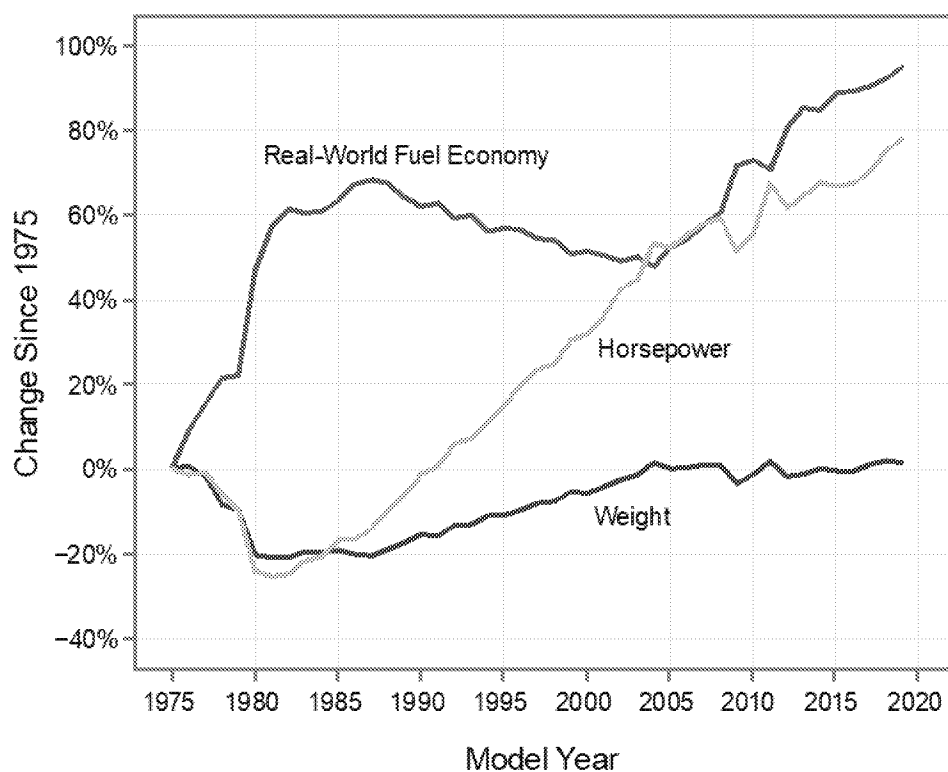
Over time, automotive technology innovation has been applied to vehicle design with differing emphasis between vehicle weight, power, CO_2 emissions, and fuel economy. In the two decades before model year 2004, technology innovation was generally used to

increase vehicle power, and weight increased due to changing vehicle design, increased vehicle size, and increased content. During this period, average new vehicle fuel economy steadily decreased, and CO_2 emissions correspondingly increased. However, since model year 2004, technology has been used to increase fuel economy (up 30%) and power (up 14%), while maintaining vehicle weight and reducing CO_2 emissions (down 23%). The improvement in CO_2 emissions and fuel economy since 2004 is due to many factors, including gasoline prices, consumer preference, and increasing stringency of NHTSA light-duty car and truck CAFE standards.

Vehicle fuel economy and CO_2 emissions are clearly related to vehicle attributes investigated in this section, namely weight, horsepower, and footprint. Future trends in fuel economy and CO_2 emissions will be dependent, at least in part, by design choices related to these attributes.

Table 3.1. Vehicle Attributes by Model Year

Model Year	Real-World CO$_2$ (g/mi)	Real-World FE (mpg)	Weight (lbs)	Horsepower (HP)	0 to 60 (s)	Footprint (ft^2)	Car Production Share	Truck Production Share
1975	681	13.1	4,060	137	-	-	80.7%	19.3%
1980	466	19.2	3,228	104	15.6	-	83.5%	16.5%
1985	417	21.3	3,271	114	14.1	-	75.2%	24.8%
1990	420	21.2	3,426	135	11.5	-	70.4%	29.6%
1995	434	20.5	3,613	158	10.1	-	63.5%	36.5%
2000	450	19.8	3,821	181	9.8	-	58.8%	41.2%
2001	453	19.6	3,879	187	9.5	-	58.6%	41.4%
2002	457	19.5	3,951	195	9.4	-	55.2%	44.8%
2003	454	19.6	3,999	199	9.3	-	53.9%	46.1%
2004	461	19.3	4,111	211	9.1	-	52.0%	48.0%
2005	447	19.9	4,059	209	9.0	-	55.6%	44.4%
2006	442	20.1	4,067	213	8.9	-	57.9%	42.1%
2007	431	20.6	4,093	217	8.9	-	58.9%	41.1%
2008	424	21.0	4,085	219	8.9	48.9	59.3%	40.7%
2009	397	22.4	3,914	208	8.8	47.9	67.0%	33.0%
2010	394	22.6	4,001	214	8.8	48.5	62.8%	37.2%
2011	399	22.3	4,126	230	8.5	49.5	57.8%	42.2%
2012	377	23.6	3,979	222	8.5	48.8	64.4%	35.6%
2013	368	24.2	4,003	226	8.4	49.1	64.1%	35.9%
2014	369	24.1	4,060	230	8.3	49.7	59.3%	40.7%
2015	360	24.6	4,035	229	8.3	49.4	57.4%	42.6%
2016	359	24.7	4,035	230	8.3	49.5	55.3%	44.7%
2017	357	24.9	4,093	234	8.2	49.8	52.5%	47.5%
2018	353	25.1	4,137	241	8.0	50.4	47.9%	52.1%
2019 (prelim)	*346*	*25.5*	*4,110*	*244*	*7.8*	*50.2*	*49.8%*	*50.2%*

To explore this data in more depth, please see the report website at https://www.epa.gov/automotive-trends.

Table 3.2. Estimated Real-World Fuel Economy and CO_2 by Vehicle Type

Model Year	Sedan/Wagon			Car SUV			Truck SUV			Minivan/Van			Pickup		
	Prod Share	Real-World CO_2 (g/mi)	Real-World FE (mpg)	Prod Share	Real-World CO_2 (g/mi)	Real-World FE (mpg)	Prod Share	Real-World CO_2 (g/mi)	Real-World FE (mpg)	Prod Share	Real-World CO_2 (g/mi)	Real-World FE (mpg)	Prod Share	Real-World CO_2 (g/mi)	Real-World FE (mpg)
1975	80.6%	660	13.5	0.1%	799	11.1	1.7%	806	11.0	4.5%	800	11.1	13.1%	746	11.9
1980	83.5%	446	20.0	0.0%	610	14.6	1.6%	676	13.2	2.1%	629	14.1	12.7%	541	16.5
1985	74.6%	387	23.0	0.6%	443	20.1	4.5%	538	16.5	5.9%	537	16.5	14.4%	489	18.2
1990	69.8%	381	23.3	0.5%	472	18.8	5.1%	541	16.4	10.0%	498	17.8	14.5%	511	17.4
1995	62.0%	379	23.4	1.5%	499	17.8	10.5%	555	16.0	11.0%	492	18.1	15.0%	526	16.9
2000	55.1%	388	22.9	3.7%	497	17.9	15.2%	555	16.0	10.2%	478	18.6	15.8%	534	16.7
2001	53.9%	386	23.0	4.8%	472	18.8	17.3%	541	16.4	7.9%	493	18.0	16.1%	557	16.0
2002	51.5%	385	23.1	3.7%	460	19.3	22.3%	545	16.3	7.7%	475	18.7	14.8%	564	15.8
2003	50.2%	382	23.3	3.6%	446	19.9	22.6%	541	16.4	7.8%	468	19.0	15.7%	553	16.1
2004	48.0%	384	23.1	4.1%	445	20.0	25.9%	539	16.5	6.1%	464	19.2	15.9%	565	15.7
2005	50.5%	379	23.5	5.1%	440	20.2	20.6%	531	16.7	9.3%	460	19.3	14.5%	561	15.8
2006	52.9%	382	23.3	5.0%	434	20.5	19.9%	518	17.2	7.7%	455	19.5	14.5%	551	16.1
2007	52.9%	369	24.1	6.0%	431	20.6	21.7%	503	17.7	5.5%	456	19.5	13.8%	550	16.2
2008	52.7%	366	24.3	6.6%	419	21.2	22.1%	489	18.2	5.7%	448	19.8	12.9%	539	16.5
2009	60.5%	351	25.3	6.5%	403	22.0	18.4%	461	19.3	4.0%	443	20.1	10.6%	526	16.9
2010	54.5%	340	26.2	8.2%	386	23.0	20.7%	452	19.7	5.0%	442	20.1	11.5%	527	16.9
2011	47.8%	344	25.8	10.0%	378	23.5	25.5%	449	19.8	4.3%	424	20.9	12.3%	516	17.2
2012	55.0%	322	27.6	9.4%	381	23.3	20.6%	445	20.0	4.9%	418	21.3	10.1%	516	17.2
2013	54.1%	313	28.4	10.0%	365	24.3	21.8%	427	20.8	3.8%	422	21.1	10.4%	509	17.5
2014	49.2%	313	28.4	10.1%	364	24.4	23.9%	412	21.6	4.3%	418	21.3	12.4%	493	18.0
2015	47.2%	306	29.0	10.2%	353	25.1	28.1%	406	21.9	3.9%	408	21.8	10.7%	474	18.8
2016	43.8%	303	29.2	11.5%	338	26.2	29.1%	400	22.2	3.9%	410	21.7	11.7%	471	18.9
2017	41.0%	293	30.2	11.5%	339	26.2	31.8%	398	22.3	3.6%	399	22.2	12.1%	470	18.9
2018	36.7%	286	30.8	11.3%	324	27.3	35.1%	384	23.1	3.1%	389	22.8	13.9%	466	19.1
2019 (prelim)	38.5%	283	30.8	11.3%	327	27.0	33.1%	375	23.7	3.4%	387	22.8	13.8%	459	19.4

To explore this data in more depth, please see the report website at https://www.epa.gov/automotive-trends.

Table 3.3. Model Year 2018 Vehicle Attributes by Manufacturer

Manufacturer	Real-World CO$_2$ (g/mi)	Real-World FE (mpg)	Weight (lbs)	HP	0 to 60 (s)	Footprint (ft^2)
BMW	339	26.0	4,190	268	6.8	48.3
FCA	409	21.7	4,465	278	7.5	52.0
Ford	397	22.4	4,476	284	7.5	55.3
GM	386	23.0	4,543	269	7.9	54.4
Honda	296	30.0	3,595	202	8.1	47.4
Hyundai	311	28.6	3,470	175	8.9	46.6
Kia	319	27.8	3,521	182	8.7	46.9
Mazda	310	28.7	3,769	187	8.9	46.5
Mercedes	377	23.5	4,430	285	7.0	49.6
Nissan	327	27.1	3,806	201	8.9	47.8
Subaru	310	28.7	3,680	177	9.4	45.0
Tesla	0	113.7	4,523	393	4.7	50.4
Toyota	348	25.5	4,083	220	8.4	48.8
VW	361	24.6	4,168	251	7.6	48.4
Other	351	25.3	4,201	240	8.4	48.1
All Manufacturers	**353**	**25.1**	**4,137**	**241**	**8.0**	**50.4**

To explore this data in more depth, please see the report website at https://www.epa.gov/automotive-trends.

Table 3.4. Model Year 2018 Estimated Real-World Fuel Economy and CO_2 by Manufacturer and Vehicle Type

Manufacturer	Sedan/Wagon Prod Share	Real-World CO_2 (g/mi)	Real-World FE (mpg)	Car SUV Prod Share	Real-World CO_2 (g/mi)	Real-World FE (mpg)	Truck SUV Prod Share	Real-World CO_2 (g/mi)	Real-World FE (mpg)	Minivan/Van Prod Share	Real-World CO_2 (g/mi)	Real-World FE (mpg)	Pickup Prod Share	Real-World CO_2 (g/mi)	Real-World FE (mpg)
BMW	73.2%	322	27.3	-	-	-	26.8%	387	22.9	-	-	-	-	-	-
FCA	12.1%	397	22.4	7.5%	339	26.2	55.3%	411	21.6	13.0%	386	22.9	12.1%	483	18.5
Ford	22.0%	313	28.4	12.2%	349	25.5	29.8%	416	21.4	1.7%	418	21.3	34.2%	450	19.8
GM	22.5%	297	29.6	14.7%	308	28.9	30.6%	405	22.0	-	-	-	32.2%	466	19.1
Honda	53.7%	263	33.6	9.7%	294	30.2	28.4%	332	26.7	6.9%	382	23.3	1.3%	408	21.8
Hyundai	59.6%	279	31.8	37.3%	353	25.2	3.1%	431	20.6	-	-	-	-	-	-
Kia	67.9%	290	30.6	11.2%	346	25.7	17.4%	397	22.4	3.5%	426	20.9		-	-
Mazda	45.4%	288	30.9	18.5%	311	28.6	36.1%	337	26.3	-	-	-	-	-	-
Mercedes	46.0%	343	25.9	11.5%	339	26.2	40.2%	426	20.8	2.2%	413	21.5	-	-	-
Nissan	57.0%	294	30.1	10.5%	295	30.1	23.8%	369	24.1	1.0%	353	25.2	7.7%	481	18.5
Subaru	22.3%	312	28.4	-	-	-	77.7%	309	28.8	-	-	-	-	-	-
Tesla	87.8%	0	118.0	8.7%	0	89.9	3.5%	0	90.3	-	-	-	-	-	-
Toyota	39.9%	267	33.2	11.0%	336	26.4	32.9%	389	22.8	2.8%	397	22.4	13.4%	489	18.2
VW	44.8%	326	27.2	0.4%	380	23.4	54.9%	389	22.8	-	-	-	-	-	-
Other	20.6%	294	30.2	8.9%	330	27.0	68.6%	372	23.9	1.9%	338	26.3	-	-	-
All Manufacturers	**36.7%**	**286**	**30.8**	**11.3%**	**324**	**27.3**	**35.1%**	**384**	**23.1**	**3.1%**	**389**	**22.8**	**13.9%**	**466**	**19.1**

To explore this data in more depth, please see the report website at https://www.epa.gov/automotive-trends.

Table 3.5. Footprint by Manufacturer for Model Year 2017–2019 (ft²)

Manufacturer	Final MY 2017			Final MY 2018			Preliminary MY 2019		
	Car	Truck	All	Car	Truck	All	Car	Truck	All
BMW	46.7	50.6	47.9	47.3	51.1	48.3	46.6	51.5	48.6
FCA	47.4	54.1	52.8	48.9	52.8	52.0	48.1	54.3	52.7
Ford	46.9	57.3	52.5	46.6	59.9	55.3	47.6	58.9	55.1
GM	46.6	58.9	53.5	46.4	59.2	54.4	46.2	57.5	53.6
Honda	45.9	49.7	47.1	46.3	49.4	47.4	46.9	50.3	48.0
Hyundai	46.3	49.2	46.5	46.5	49.2	46.6	46.6	49.2	47.0
Kia	46.1	50.0	47.2	46.2	49.5	46.9	47.1	49.1	47.5
Mazda	45.5	47.2	46.0	45.6	47.9	46.5	45.3	47.7	46.3
Mercedes	48.5	52.0	50.0	48.3	51.3	49.6	47.9	51.3	48.8
Nissan	46.1	51.9	48.0	46.0	51.7	47.8	46.2	52.4	48.3
Subaru	45.1	45.0	45.0	44.9	45.0	45.0	44.8	45.8	45.6
Tesla	53.8	-	53.8	50.3	54.8	50.4	50.0	54.8	50.1
Toyota	45.6	52.6	49.0	46.1	51.6	48.8	46.0	51.6	48.8
VW	45.0	50.2	46.3	45.9	50.5	48.4	45.5	51.1	47.6
Other	44.6	49.3	47.3	45.0	49.4	48.1	46.0	48.9	48.1
All Manufacturers	**46.2**	**53.8**	**49.8**	**46.5**	**53.9**	**50.4**	**46.7**	**53.6**	**50.2**

To explore this data in more depth, please see the report website at https://www.epa.gov/automotive-trends.

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4. Vehicle Technology

Since model year 1975, the technology used in vehicles has continually evolved. Today's vehicles utilize an increasingly wide array of technological solutions developed by the automotive industry to improve vehicle attributes discussed previously in this report, including CO_2 emissions, fuel economy, vehicle power, and acceleration. Automotive engineers and designers are constantly creating and evaluating new technology and deciding how, or if, it should be applied to their vehicles.

This section of the report focuses on three separate technological areas of a vehicle: the engine, transmission, and driveline. The engine (or motor) of an automobile is at the heart of any vehicle design and converts energy stored in fuel (or a battery) into rotational energy. The transmission converts the rotational energy from the relatively narrow range of speeds available at the engine to the appropriate speed required for the driving conditions. The driveline transfers the rotational energy from the transmission to the two or four wheels being used to move the vehicle. Each of these components has energy losses, or inefficiencies, which ultimately increase vehicle CO_2 emissions and decrease fuel economy. A basic illustration of the energy flow through a vehicle is shown in Figure 4.1. Hybrid vehicles, electric vehicles (EVs), and plug-in hybrid electric vehicles (PHEVs) may have somewhat different configurations than shown in Figure 4.1.

Figure 4.1. Vehicle Energy Flow
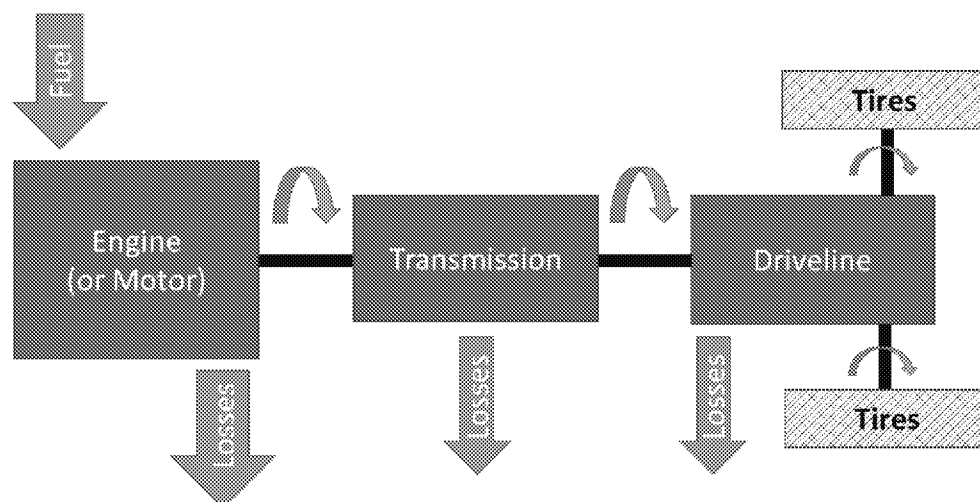
Manufacturers are adopting many new technologies to improve efficiency. Figure 4.2 illustrates projected manufacturer-specific technology adoption, with larger circles representing higher adoption rates, for model year 2019. The figure shows preliminary model year 2019 technology projections to provide insight on a quickly changing industry, even though there is some uncertainty in the preliminary data.

Figure 4.2. Manufacturer Use of Emerging Technologies for Model Year 2019

	Turbo	GDI	CVT	7+Gears	CD	StopStart	Hybrid	PHEV/EV/FCV
Tesla								100%
Honda	54%	83%	50%	40%	21%	5%	4%	1%
Subaru	14%	70%	93%			28%		1%
Mazda	27%	95%			54%	0%		
Hyundai	15%	82%		27%		3%	4%	2%
Kia	10%	86%	13%	22%		6%	8%	2%
Nissan	7%	39%	80%	10%		1%	0%	3%
BMW	98%	98%		84%		85%		4%
Toyota	3%	1%	26%	51%		12%	9%	0%
VW	86%	99%		89%	0%	82%	3%	1%
Mercedes	98%	100%		100%	4%	91%	3%	2%
GM	40%	90%	4%	49%	47%	62%	0%	2%
Ford	65%	46%	5%	54%		75%	5%	0%
FCA	14%	13%	1%	84%	19%	52%	16%	1%
All Manufacturers	34%	54%	24%	48%	13%	36%	6%	3%
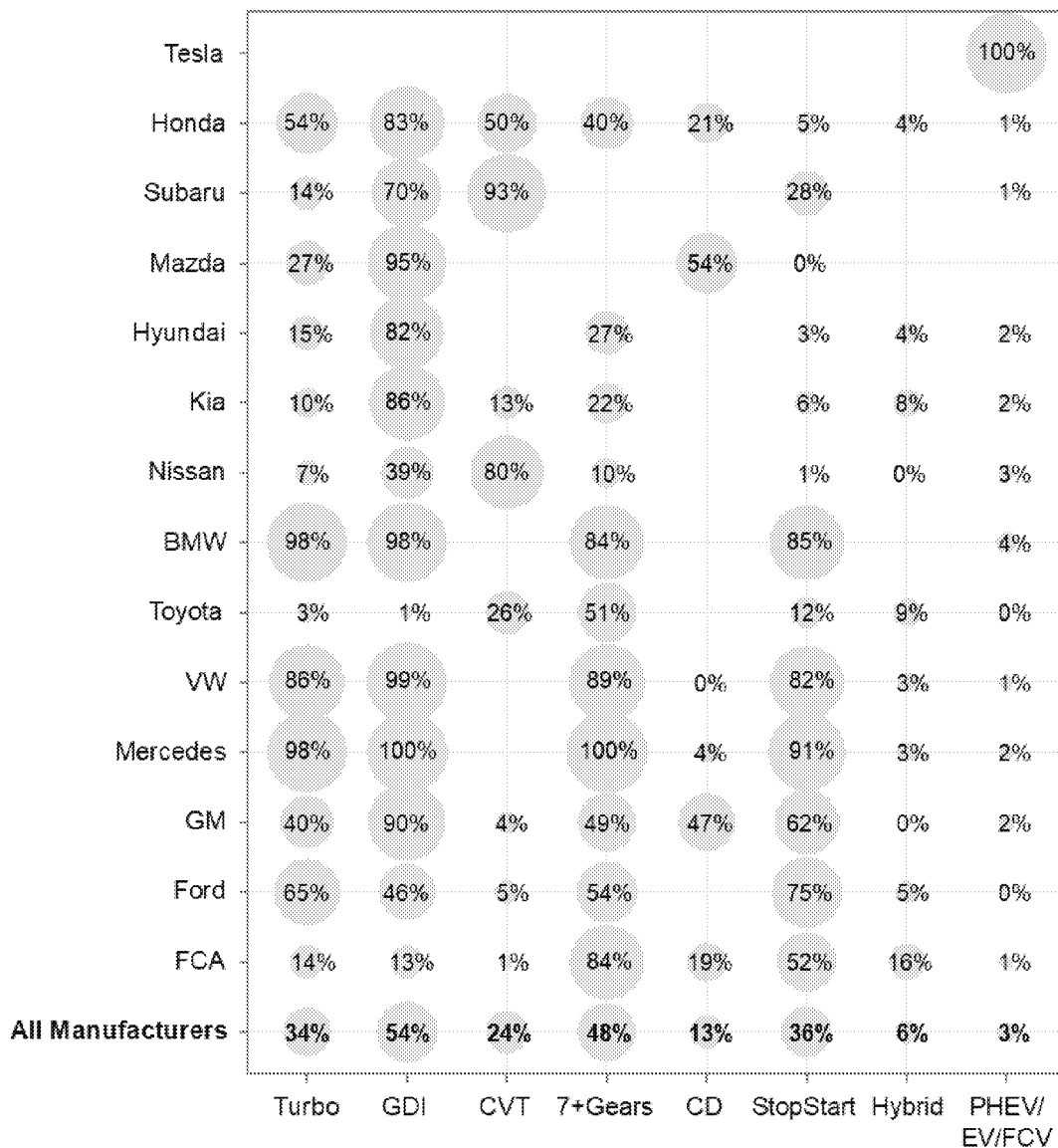
Engine technologies such as turbocharged engines (Turbo) and gasoline direct injection (GDI) allow for more efficient engine design and operation. Cylinder deactivation (CD) allows for only using part of the engine when less power is needed, and stop/start can turn off the engine entirely when the vehicle is stopped to save fuel. Hybrid vehicles use a larger

battery to recapture braking energy and provide power when necessary, allowing for a smaller, more efficiently-operated engine. Transmissions that have seven or more speeds, and continuously variable transmissions (CVTs), allow the engine to more frequently operate near its peak efficiency, providing more efficient average engine operation and a reduction in fuel usage.

The technologies in Figure 4.2 are all being adopted by manufacturers to reduce CO_2 emissions and increase fuel economy. In some cases, the adoption is rapid. For example, GDI was used in fewer than 3% of vehicles as recently as model year 2008 but is projected to be in more than 50% of vehicles in model year 2019. Electric vehicles (EVs), plug-in hybrid electric vehicles (PHEVs), and fuel cell vehicles (FCVs) are a small but growing percentage of new vehicles.

Each of the fourteen manufacturers shown in Figure 4.2 have included at least four of these technologies in their new vehicles (except Tesla, which cannot apply many of these technologies to their electric vehicles). However, it is also clear that manufacturers' strategies to develop and adopt new technologies are unique and can vary significantly. Each manufacturer is choosing technologies that best meet the design requirements of their vehicles, and in many cases, that technology is changing quickly. The rest of this section will explore how engine, transmission, and driveline technology has changed since 1975, the impact of those technology changes, and the rate at which technology is adopted by the industry.

A. Engines

Vehicle engine technology has continually evolved in the 40+ years since EPA began collecting data. Over that time, engines using gasoline as a fuel have dominated the market, and the technology on those engines has changed dramatically. More recently, new engine designs such as PHEVs, EVs, and FCVs have begun to enter the market, potentially offering dramatic reductions in tailpipe CO_2 emissions and further increases in fuel economy.

The trend in engine technology since model year 1975 is shown in Figure 4.3. Vehicles that use an engine that operates exclusively on gasoline (including hybrids, but not plug-in hybrids which also use electricity) have held at least 95% of the light-duty vehicle market in almost every year. Vehicles with diesel engines briefly captured almost 6% of the market in model year 1981 but have been less than 1% of the market in most other years. PHEVs, EVs, and FCVs have added to the increasing array of technology available in the automotive marketplace and have been capturing a small but growing portion of the market.

Figure 4.3. Production Share by Engine Technology

Fuel Delivery	Valve Timing	Number of Valves	Key
Carbureted	Fixed	Two-Valve	1
		Multi-Valve	2
Throttle Body Injection	Fixed	Two-Valve	3
		Multi-Valve	4
Port Fuel Injection	Fixed	Two-Valve	5
		Multi-Valve	6
	Variable	Two-Valve	7
		Multi-Valve	8
Gasoline Direct Injection (GDI)	Fixed	Multi-Valve	9
	Variable	Multi-Valve	10
		Two-Valve	11
Diesel	—	—	12
EV/PHEV/FCV	—	—	13

Engines that use only gasoline as a fuel (including hybrids) are further divided based on three broad parameters for Figure 4.3: fuel delivery, valve timing, and number of valves per cylinder. All of these parameters enable better control of the combustion process, which in turn can allow for lower CO_2 emissions, increased fuel economy, and/or more power. Fuel delivery refers to the method of creating an air and fuel mixture for combustion. The technology for fuel delivery has changed over time from carburetors to fuel injection systems located in the intake system, and more recently to gasoline direct injection (GDI) systems that spray gasoline directly into the engine cylinder.

The valves on each cylinder of the engine determine the amount and timing of air entering and exhaust gases exiting the cylinder during the combustion process. Valve timing has evolved from fixed timing to variable valve timing (VVT), which can allow for much more precise control. In addition, the number of valves per cylinder has generally increased, again offering more control of air and exhaust flows. All of these changes have led to modern engines with much more precise control of the combustion process.

Figure 4.3 shows many different engine designs as they have entered, and in many cases exited, the automotive market. Some fleetwide changes occurred gradually, but in some cases (for example trucks in the late 1980s), engine technology experienced widespread change in only a few years. Evolving technology offers opportunities to improve fuel economy, CO_2 emissions, power, and other vehicle parameters. The following analysis will look at technology trends within gasoline engines (including hybrids), PHEVs and EVs, and diesel engines. Each of these categories of engine technologies has unique properties, metrics, and trends over time.

Gasoline Engines

Since EPA began tracking vehicle data in 1975, nearly 600 million vehicles have been produced for sale in the United States. For most of those years, vehicles relying on a gasoline engine as the only source of power captured more than 99% of production. The only exceptions were in the early 1980s when diesel engines peaked briefly at about 6% of the market, and more recently as electric vehicles have captured some of the market. For the purposes of this report, hybrid vehicles are included with gasoline engines, as are "flex fuel" vehicles that are capable of operating on gasoline or a blend of 85% ethanol and 15% gasoline (E85).

Engine Size and Displacement

Engine size is generally described in one of two ways, either the number of cylinders or the total displacement of the engine (the total volume of the cylinders). Engine size is important because larger engines strongly correlate with higher fuel use. Figure 4.4 shows the trends in gasoline engine size over time, as measured by number of cylinders.

Figure 4.4. Gasoline Engine Production Share by Number of Cylinders
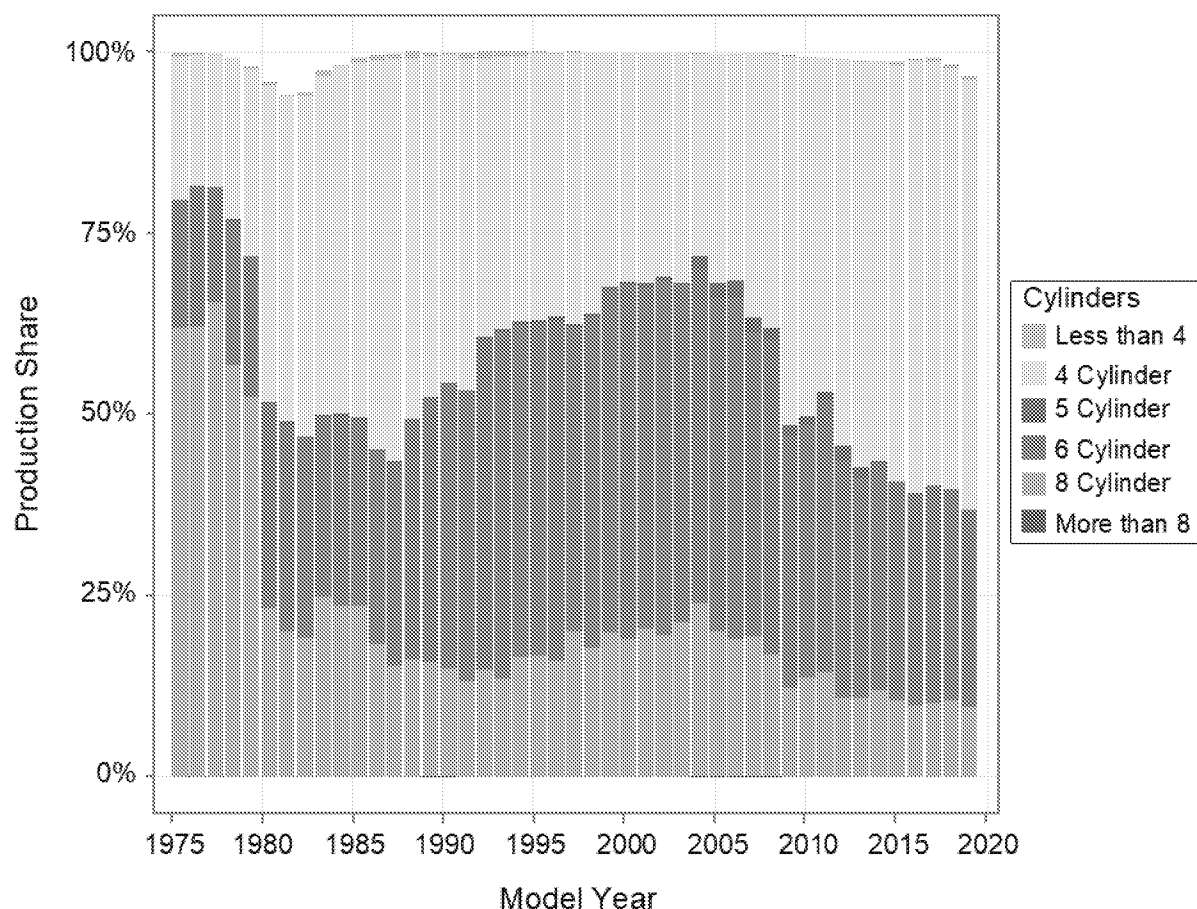
In the mid and late 1970s, the 8-cylinder engine was dominant, accounting for well over half of all new vehicle production. In model year 1980 there was a significant change in the market, as 8-cylinder engine production share dropped to about one quarter of the market and 4-cylinder production share increased to 45% of the market. Between model year 1980 and model year 1992, 4-cylinder engines were the most popular engines, although they slowly lost ground to 6-cylinder engines, and in model year 1992, 6-cylinder engines became the most popular engine option. In model year 2009, 4-cylinder engines increased 13 percentage points in a single year to again become the most popular engine option,

capturing a little over half of all production. Production share of 4-cylinder engines has generally increased since, and now accounts for about 60% of production in model year 2018. Production share of 8-cylinder engines has continued to decrease, to about 10%. Projected data for model year 2019 suggests these trends will continue.

Overall engine size, as measured by the total volume of all the engine's cylinders, is directly related to the number of cylinders. As vehicles have moved towards engines with a lower number of cylinders, the total engine size, or displacement, is also at an all-time low. The average new vehicle in model year 1975 had a displacement of nearly 300 cubic inches, compared to an average of 172 cubic inches today. Gasoline engine displacement per cylinder has been relatively stable over the time of this report (around 35 cubic inches per cylinder since 1980), so the reduction in overall new vehicle engine displacement is almost entirely due to the shift towards engines with fewer cylinders.

The contrasting trends in horsepower (at all-time high) and engine displacement (at an all-time low) highlight the continuing improvement in engines. These improvements are due to the development of new technologies and ongoing design improvements that allow for more efficient use of fuel or reduce internal engine friction. One additional way to examine the relationship between engine horsepower and displacement is to look at the trend in *specific* power (HP/Displacement), which is a metric to compare the power output of an engine relative to its size.

Specific power has increased nearly 200% since model year 1975. The rate at which specific power has increased has been remarkably steady, as shown in Figure 4.5. The specific power of new vehicle gasoline engines has increased by about 0.02 horsepower per cubic inch every year for 40+ years. Considering the numerous and significant changes to engines over this time span, changes in consumer preferences, and the external pressures on vehicle purchases, the long-standing linearity of this trend is noteworthy. The roughly linear increase in specific power does not appear to be slowing. Turbocharged engines, direct injection, higher compression ratios, and many other engine technologies are likely to continue increasing engine specific power.

Figure 4.5 also shows two other important engine metrics, the amount of fuel consumed compared to the overall size of the engine (Fuel Consumption/Displacement), and the amount of fuel consumed relative to the amount of power produced by an engine (Fuel Consumption/HP). The amount of fuel consumed by a gasoline engine, relative to the total displacement, has fallen about 12% since model year 1975, and fuel consumption relative to engine horsepower has fallen almost 70% since model year 1975. Taken as a whole, the trend lines in Figure 4.5 clearly show that gasoline engine improvements over time have

been steady and continual, and have resulted in impressive improvements to internal combustion engines.

Figure 4.5. Percent Change for Specific Gasoline Engine Metrics
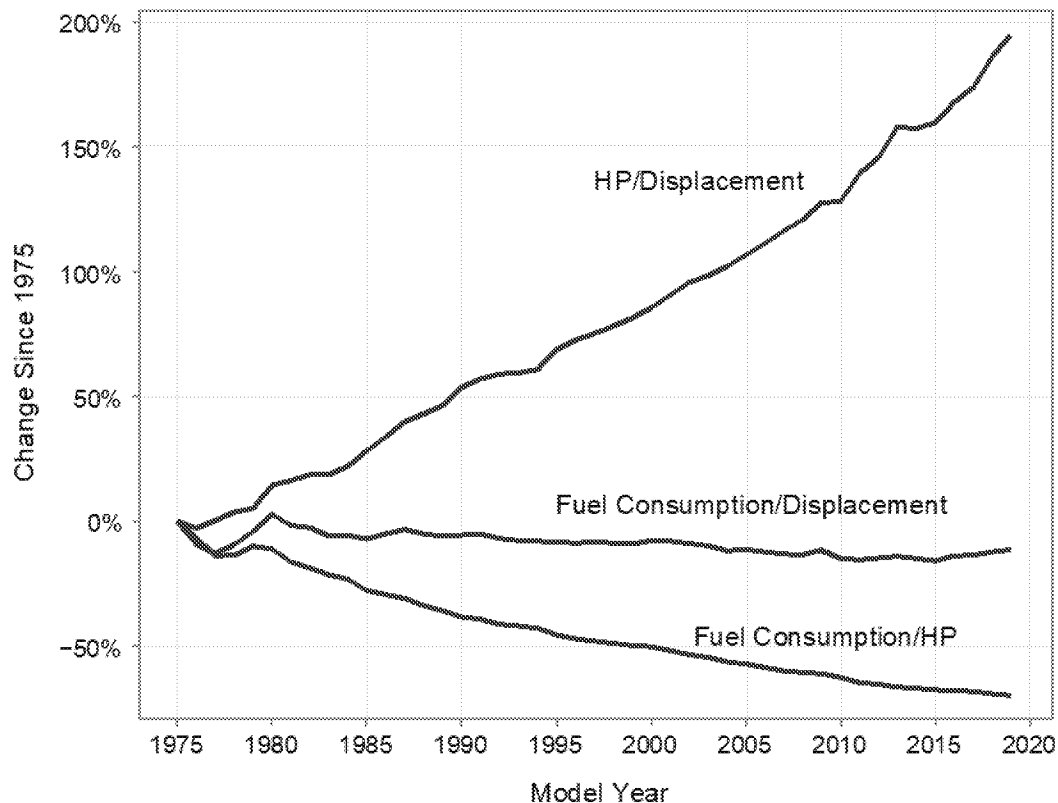
Fuel Delivery Systems and Valvetrains

All gasoline engines require a fuel delivery system that controls the flow of fuel delivered into the engine. The process for controlling fuel flow has changed significantly over time, allowing for much more control over the combustion process and thus more efficient engines. In the 1970s and early 1980s, nearly all gasoline engines used carburetors to meter fuel delivered to the engine. Carburetors were replaced over time with fuel injection systems; first throttle body injection (TBI) systems, then port fuel injection (PFI) systems, and more recently gasoline direct injection (GDI), as shown in Figure 4.3. TBI and PFI systems use fuel injectors to electronically deliver fuel and mix it with air outside of the engine cylinder; the resulting air and fuel mixture is then delivered to the engine cylinders for combustion. Engines that utilize GDI spray fuel directly into the air in the engine cylinder for better control of the combustion process. Engines using GDI were first introduced into the market with very limited production in model year 2007. Ten years

later, GDI engines were installed in 50% of model year 2018 gasoline vehicles and are projected to continue increasing.

Another key aspect of engine design is the valvetrain. Each engine cylinder must have a set of valves that allow for air (or an air/fuel mixture) to flow into the engine cylinder prior to combustion and for exhaust gases to exit the cylinder after combustion. The number of valves per cylinder and the method of controlling the valves (i.e., the valvetrain) directly impacts the overall efficiency of the engine. Generally, engines with four valves per cylinder instead of two, and valvetrains that can alter valve timing during the combustion cycle can provide more engine control and increase engine power and efficiency.

This report began tracking multi-valve engines (i.e., engines with more than two valves per cylinder) for cars in model year 1986 and for trucks in model year 1994. Since that time nearly the entire fleet has converted to multi-valve design. While some three- and five-valve engines have been produced, the vast majority of multi-valve engines are based on four valves per cylinder. Engines with four valves generally use two valves for air intake and two valves for exhaust. In addition, this report began tracking variable valve timing (VVT) technology for cars in model year 1990 and for trucks in model year 2000, and since then nearly the entire fleet has adopted this technology. Figure 4.3 shows the evolution of engine technology, including fuel delivery method and the introduction of VVT and multi-valve engines.

As shown in Figure 4.3, fuel delivery and valvetrain technologies have often been developed simultaneously. Nearly all carbureted engines relied on fixed valve timing and had two valves per cylinder, as did early port-injected engines. Port-injected engines largely developed into engines with both multi-valve and VVT technology. Engines with GDI are almost exclusively using multi-valve and VVT technology. These four engine groupings, or packages, represent a large share of the engines produced over the timespan covered by this report.

Figure 4.6 shows the changes in specific power and fuel consumption per horsepower for each of these engine packages over time. There is a very clear increase in specific power of each engine package as engines moved from carbureted engines, to engines with two valves, fixed timing and port fuel injection, then to engines with multi-valve VVT and port fuel injection, and finally to GDI engines. Some of the increase for GDI engines may also be due to the fact that GDI engines are often paired with turbochargers to further increase power. Vehicles with fixed valve timing and two valves per cylinder have been limited in recent years, and are expected to exit production in model year 2019.

Figure 4.6. Engine Metrics for Different Gasoline Technology Packages
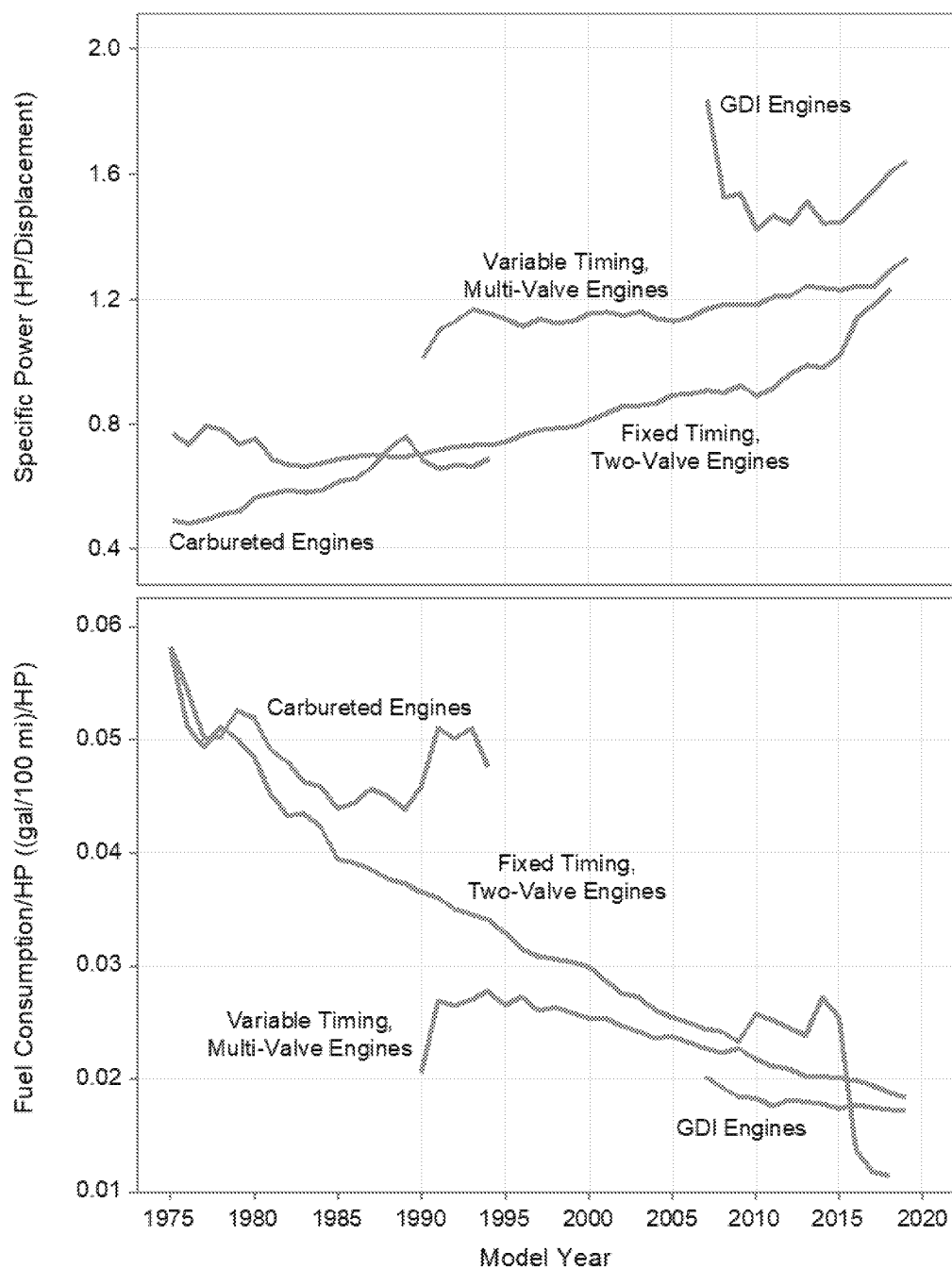
Turbocharging

Turbochargers increase the power that an engine can produce by forcing more air, and thus fuel, into the engine. An engine with a turbocharger can produce more power than an identically sized engine that is naturally aspirated or does not have a turbocharger. Turbochargers are powered using the pressure of the engine exhaust as it leaves the engine. Superchargers operate the same way as turbochargers but are directly connected to the engine for power, instead of using the engine exhaust. Alternate turbocharging and supercharging methods, such as electric superchargers, are also beginning to emerge. A limited number of new vehicles utilize both a turbocharger and supercharger in one engine package.

Turbocharged engines have been increasing rapidly in the marketplace and 34% of all engines are expected to be turbocharged gasoline engines in model year 2019, as shown in Figure 4.7. Many of these engines are applying turbochargers to create "turbo downsized" engine packages that can combine the improved fuel economy of smaller engines during normal operation but can provide the power of a larger engine by engaging the turbocharger when necessary. As evidence of this turbo downsizing, more than 80% of turbocharged engines are 4-cylinder engines, with most other turbochargers being used in 6-cylinder engines. This is shown in Figure 4.8.

Most of the current turbocharged engines also use GDI and VVT. This allows for more efficient engine operation, helps increase the resistance to premature combustion (engine knock), and reduces turbo lag (the amount of time it takes for a turbocharger to engage). In model year 2018, more than 90% of new vehicles with gasoline turbocharged engines also used GDI.

Figure 4.9 examines the distribution of engine displacement and power of turbocharged engines over time. In model year 2010, turbochargers were used mostly in cars, and were available on engines both above and below the average engine displacement. The biggest increase in turbocharger use over the last few years has been in cars with engine displacement well below the average displacement. The distribution of horsepower for turbocharged engines is much closer to the average horsepower, even though the displacement is smaller, reflecting the higher power per displacement of turbocharged engines. This trend towards adding turbochargers to smaller, less powerful engines is consistent with the turbo downsizing trend.

Figure 4.7. Gasoline Turbo Engine Production Share by Vehicle Type
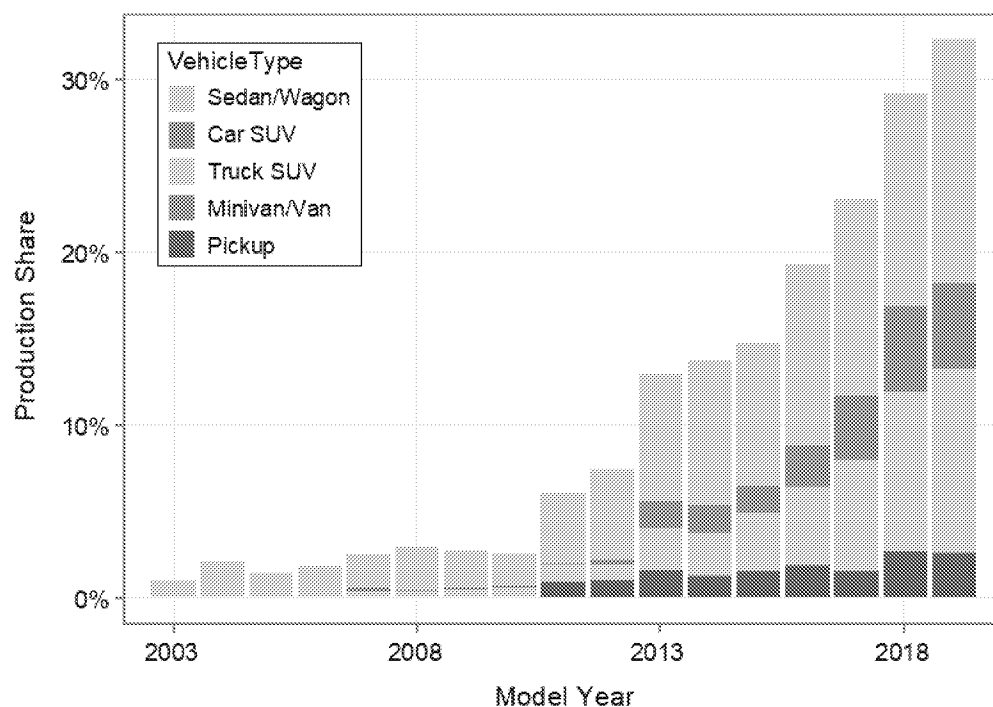
Figure 4.8. Gasoline Turbo Engine Production Share by Number of Cylinders
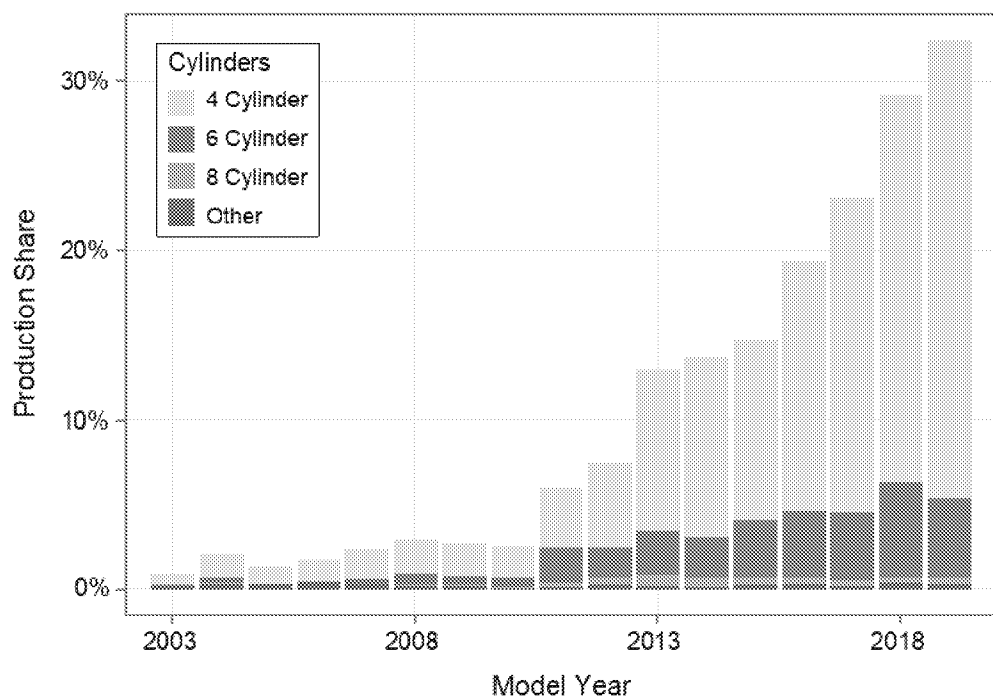
Figure 4.9. Distribution of Gasoline Turbo Vehicles by Displacement and Horsepower, Model Year 2011, 2014, and 2018
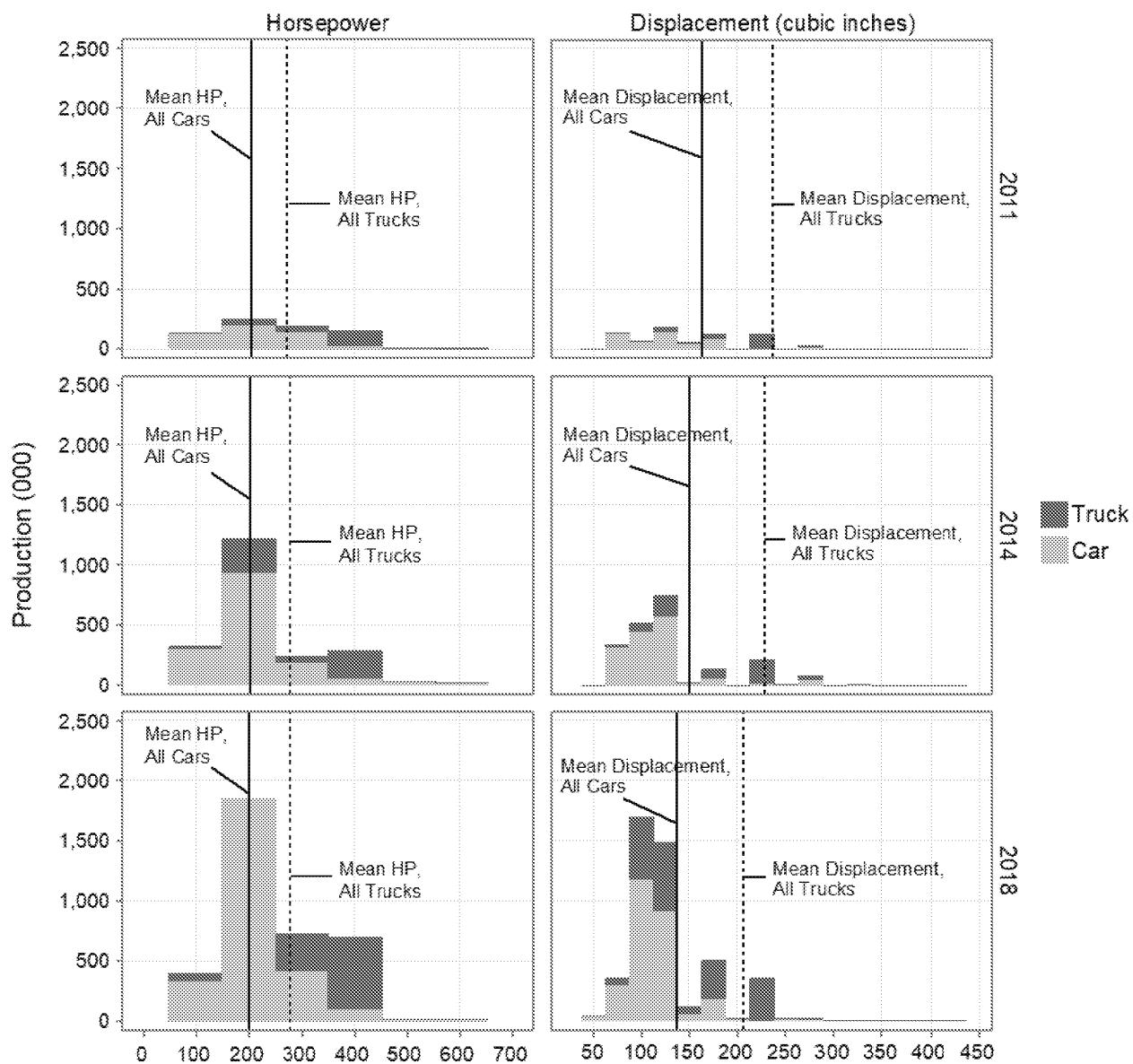
Cylinder Deactivation

Cylinder deactivation is an engine management approach that turns off the flow of fuel to one or more engine cylinders when driving conditions do not require full engine power. This effectively allows a large engine to act as a smaller engine when the additional cylinders are not needed, increasing engine efficiency and fuel economy. The use of cylinder deactivation in gasoline vehicles has been steadily climbing, and in model year 2018 gasoline engines with cylinder deactivation were 13% of all vehicles. This trend is expected to continue, especially as new improvements to cylinder deactivation technology, such as dynamic cylinder deactivation, reach the market.

Stop/Start

Engine stop/start technology allows the engine to be automatically turned off at idle and very quickly restarted when the driver releases the brake pedal. By turning the engine off, a vehicle can eliminate the fuel use and CO_2 emissions that would have occurred if the engine was left running. This report began tracking stop/start technology in model year 2012 at less than one percent, and already the use of stop/start has increased to 30% of all vehicles, with an increase to almost 36% projected for model year 2019.

Hybrids

Gasoline hybrid vehicles feature a battery pack that is larger than the battery found on a typical gasoline vehicle, which allows these vehicles to store and strategically apply electrical energy to supplement the gasoline engine. The result is that the engine can be smaller than what would be needed in a non-hybrid vehicle, and the engine can be operated near its peak efficiency more often. Hybrids also utilize regenerative braking, which uses a motor/generator to capture energy from braking instead of losing that energy to friction and heat, as in traditional friction braking, and stop/start technology to turn off the engine at idle. The combination of these strategies can result in significant reductions in fuel use and CO_2 emissions.

Hybrids were first introduced in the U.S. marketplace in model year 2000 with the Honda Insight. As more models and options were introduced, hybrid production generally increased to 3.8% of all vehicles in model year 2010. Between model years 2010 and 2018, production of hybrids remained in the range of 2–3%, as shown in Figure 4.10. Most hybrids through model year 2018 utilized 4-cylinder engines, shown in Figure 4.11.

Figure 4.10. Gasoline Hybrid Engine Production Share by Vehicle Type
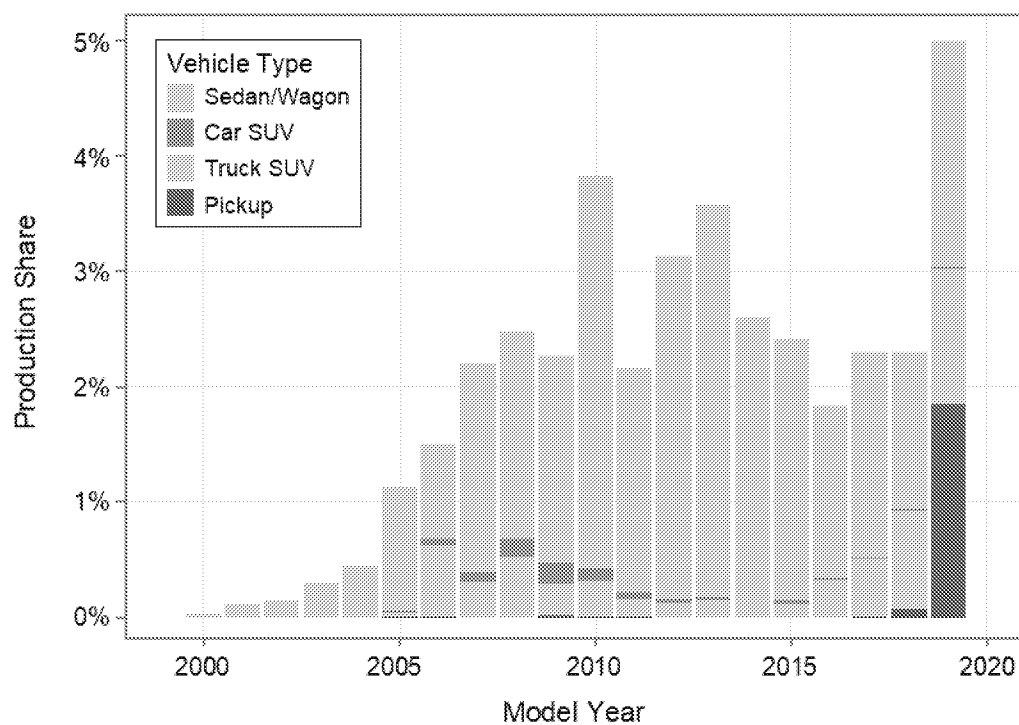
Figure 4.11. Gasoline Hybrid Engine Production Share by Number of Cylinders
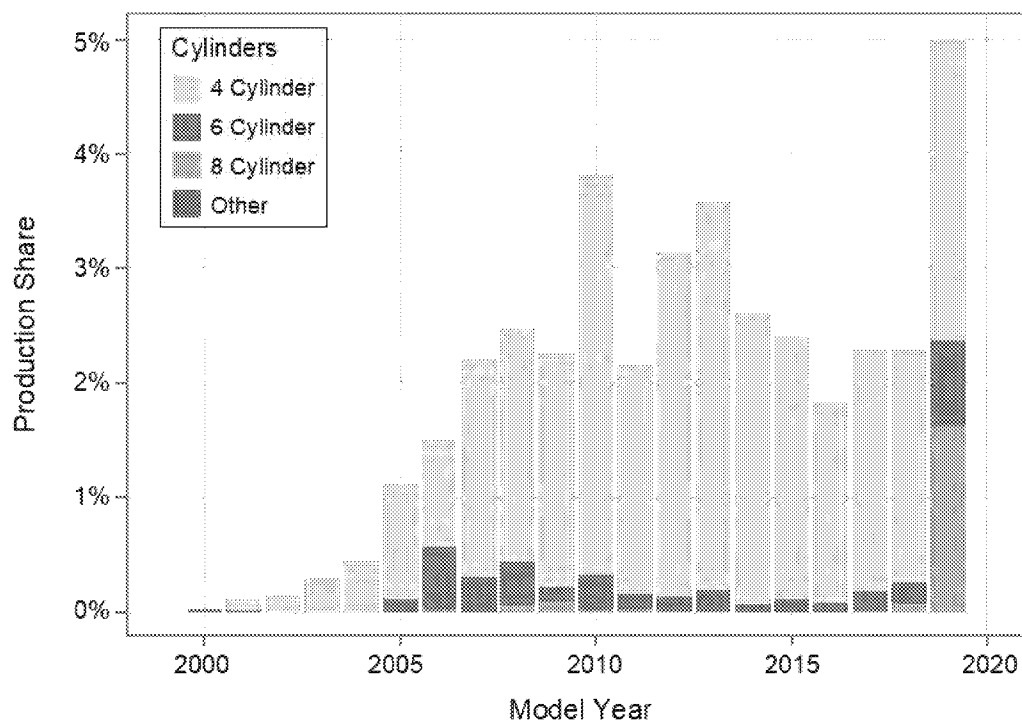
The projected data for model year 2019 shows a significant change for hybrid production, driven mostly by FCA's introduction of a "mild" hybrid into the Ram 1500 pickup truck and the Jeep Wrangler. FCA's hybrid system is expected to push overall hybrid sales to 5% of production in model year 2019. The new FCA engines also dramatically increase the number of both pickup hybrids and hybrids based on 6 or 8-cylinder engines.

The mild hybrid system used by FCA (and other manufacturers) are capable of regenerative braking and many of the same functions as other hybrids, but utilize a smaller battery and an electrical motor that cannot directly drive the vehicle. If these types of hybrids do in fact capture a significant market share, this report may disaggregate hybrids in the future for more detailed analysis.

The production-weighted distribution of fuel economy for all hybrid cars by year is shown in Figure 4.12. Hybrid cars, on average, had fuel economy more than 50% higher than the average non-hybrid car in model year 2018. As a production weighted average, hybrid cars (including sedan/wagons and car SUVs) achieved 45 mpg for model year 2018, while the average non-hybrid car achieved about 29 mpg.

Figure 4.12. Hybrid Real-World Fuel Economy Distribution, Cars Only
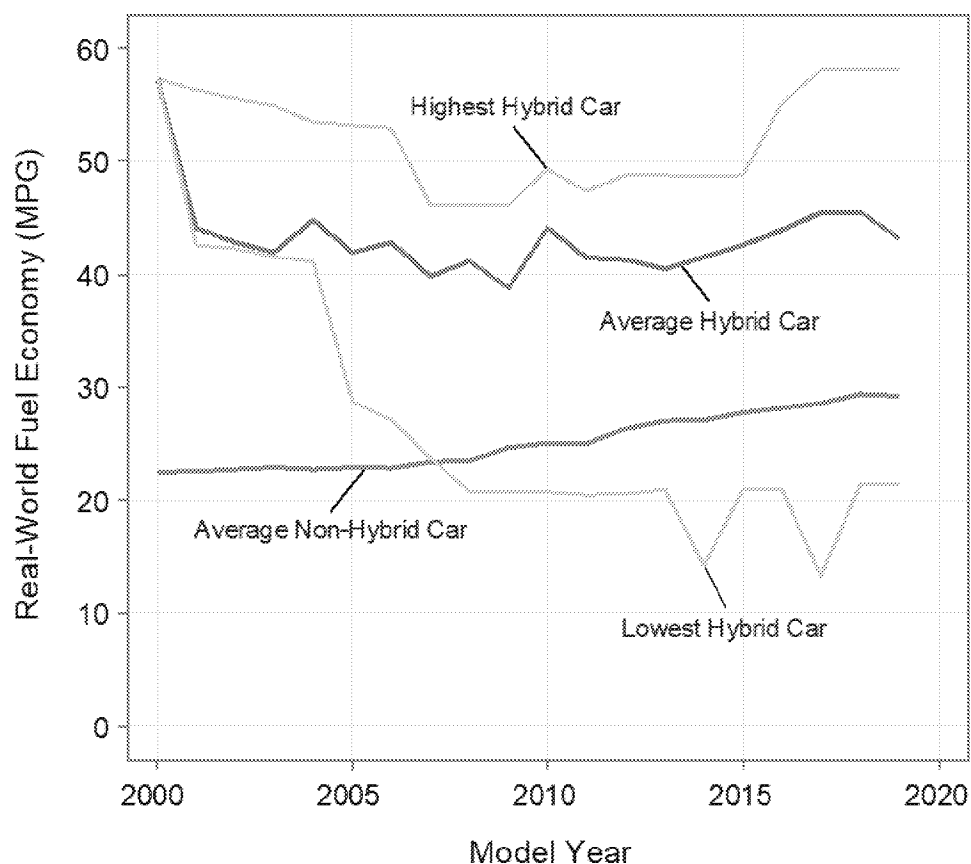
Figure 4.12 is presented only for cars since the production of hybrid trucks has been limited. While the average fuel economy of hybrid cars remains higher than the average fuel economy of non-hybrid cars, the difference has narrowed considerably. Average hybrid car fuel economy has been relatively stable since model year 2001, while the fuel economy of the average non-hybrid car has increased more than 30%.

Plug-In Hybrid Electric, Electric, and Fuel Cell Vehicles

PHEVs and EVs are two types of vehicles that can store electricity from an external source onboard the vehicle, utilizing that stored energy to propel the vehicle. PHEVs are similar to gasoline hybrids discussed previously, but the battery packs in PHEVs can be charged from an external electricity source; this cannot be done in gasoline hybrids. EVs operate using only energy stored in a battery from external charging. Fuel cell vehicles use a fuel cell to chemically convert a fuel (usually hydrogen) into electrical energy that is then used to power the vehicle.

EVs do not emit tailpipe emissions at the vehicle. However, generating the electricity used to charge EVs, in most cases, creates emissions. The amount of emissions created by charging EVs varies depending on fuel source of the electricity, which can in turn vary based on location and time of day. The electric grid in the US has also been changing over time, as natural gas and renewable energy resources have been responsible for a growing portion of electricity generation across the US. Depending on the source of electricity, EVs can result in much lower CO_2 emissions over their lifetime compared to gasoline vehicles.

Since EVs do not use gasoline, the familiar metric of miles per gallon cannot be applied to EVs. Instead, EVs are rated in terms of miles per gallon-equivalent (mpge), which is the number of miles that an EV travels on an amount of electrical energy equivalent to the energy in a gallon of gasoline. This metric enables a direct comparison of energy efficiency between EVs and gasoline vehicles. EVs generally have a much higher energy efficiency than gasoline vehicles because electric motors are much more efficient than gasoline engines.

PHEVs combine the benefits of EVs with the benefits of a gasoline hybrid. These vehicles can operate either on electricity or gasoline, allowing for a wide range of engine designs and strategies for the utilization of stored electrical energy during typical driving. The use of electricity to provide some or all of the energy required for propulsion can significantly lower fuel consumption and tailpipe CO_2 emissions. For a much more detailed discussion of EV and PHEV metrics, as well as upstream emissions from electricity, see Appendix E.

The production of EVs and PHEVs has increased rapidly in recent years. Prior to model year 2011, EVs were available, but generally only in small numbers for lease in California.[13] In model year 2011 the first PHEV, the Chevrolet Volt, was introduced along with the Nissan Leaf EV. Many additional models have been introduced since, and in model year 2018 combined EV/PHEV sales reached 2.2% of overall production, as shown in Figure 4.13.

Figure 4.13. Production Share of EVs, PHEVs, and FCVs, Model Year 1995-2019[14]
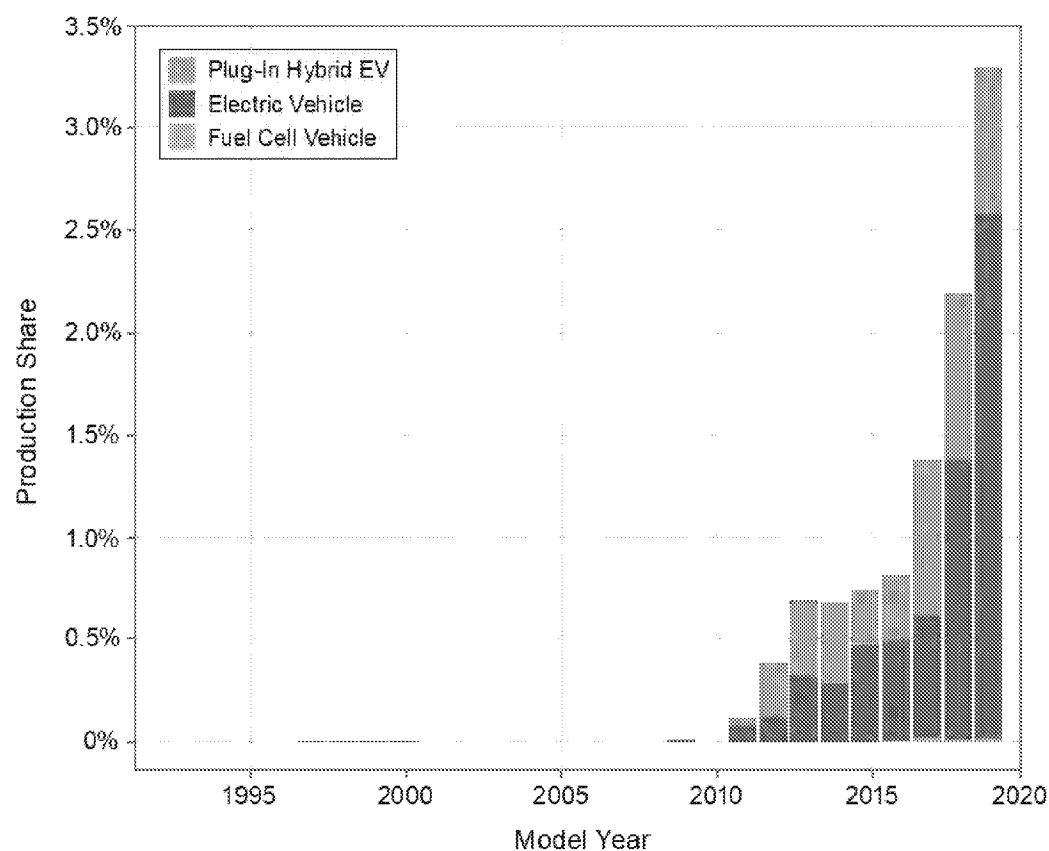
Combined EV/PHEV production is projected to reach more than 3% in model year 2019. The inclusion of model year 2018 EV and PHEV sales reduces the overall new vehicle average CO_2 emissions by 7 g/mi, and this impact will continue to grow if EV and PHEV production increases. In model year 2018 there were three hydrogen FCVs available for sale, but they

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[13] At least over the timeframe covered by this report. Electric vehicles were initially produced more than 100 years ago.

[14] EV production data were supplemented with data from Ward's and other publicly available production data for model years prior to 2011. The data only include offerings from original equipment manufacturers and does not include data on vehicles converted to alternative fuels in the aftermarket.

were only available in the state of California and in very small numbers. However there continues to be interest in FCVs as a future technology.

Figure 4.14 shows the range and fuel economy trends for EVs and PHEVs. The average range of new EVs has climbed substantially. In model year 2019 the average new EV is projected to have a 280-mile range, or more than three and a half times the range of an average EV in 2011. This difference is largely attributable to higher production of new EVs with much longer ranges. The range values shown for PHEVs are the charge-depleting range, where the vehicle is operating on energy in the battery from an external source. This is generally the electric range of the PHEV, although some vehicles also use the gasoline engine in small amounts during charge depleting operation. The average charge depleting range for PHEVs has remained unchanged since model year 2011.

Along with improving range, the fuel economy of electric vehicles has also improved as measured in miles per gallon of gasoline equivalent (mpge). The fuel economy of electric vehicles has increased almost 20% since model year 2011. The combined fuel economy of PHEVs has been more variable and does not appear to have a clear trend. For more information about EV and PHEV metrics, see Appendix E of this report.

Figure 4.14. Charge Depleting Range and Fuel Economy Trends for EVs and PHEVs
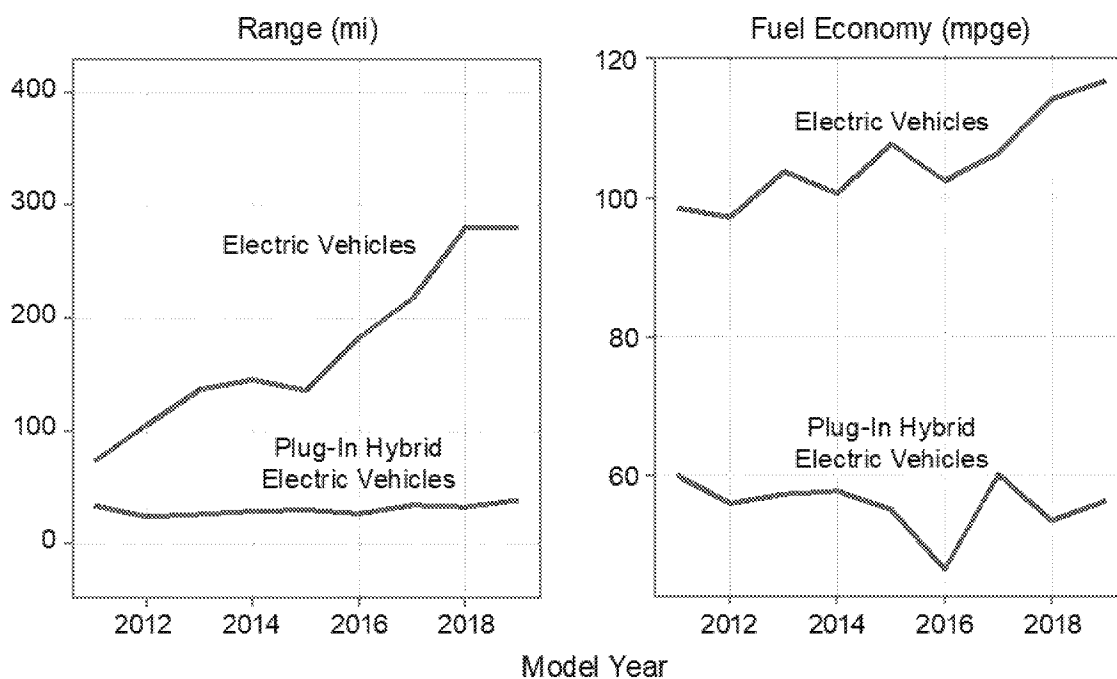
Diesel Engines

Vehicles with diesel engines have been available in the U.S. at least as long as EPA has been collecting data. However, sales of diesel vehicles have rarely broken more than 1% of the overall market. Diesel vehicle sales peaked at 5.9% of the market in model year 1981, but quickly fell back to below 1% of production per year. While the overall percentage of diesel vehicles is low, there are still new vehicles entering the market.

Vehicles that rely on diesel fuel often achieve higher fuel economy than gasoline vehicles, largely because the energy density of diesel fuel is about 15% higher than that of gasoline. However, there is less of an advantage in terms of CO_2 emissions because diesel fuel also contains about 15% more carbon per gallon, and thus emits more CO_2 per gallon burned than gasoline.

Figure 4.15 shows the production share of diesel engines by vehicle type. Diesel engines have historically been more prevalent in the sedan/wagon vehicle type, however there has been very limited diesel sedan/wagon production in recent years. Light-duty diesel pickup trucks have recently re-entered the market, although only in small volumes. This report does not include the largest pickup trucks and work or vocational trucks, which have a higher penetration of diesel engines. As shown in Figure 4.16, current production of diesel engines for light-duty vehicles is limited to smaller four- and six-cylinder engines.

Diesel engines, as with gasoline engines, have improved over time. Figure 4.17 shows the same metrics and trends that are explored in Figure 4.5 for gasoline engines. The specific power (HP/displacement) for diesel engines has increased about 200% since model year 1975. Fuel consumption per displacement dropped slightly in the 1980s but has increased back to about the same level as in model year 1975. Finally, fuel consumption per horsepower for diesel engines has declined about 75% since model year 1975.

Figure 4.15. Diesel Engine Production Share by Vehicle Type
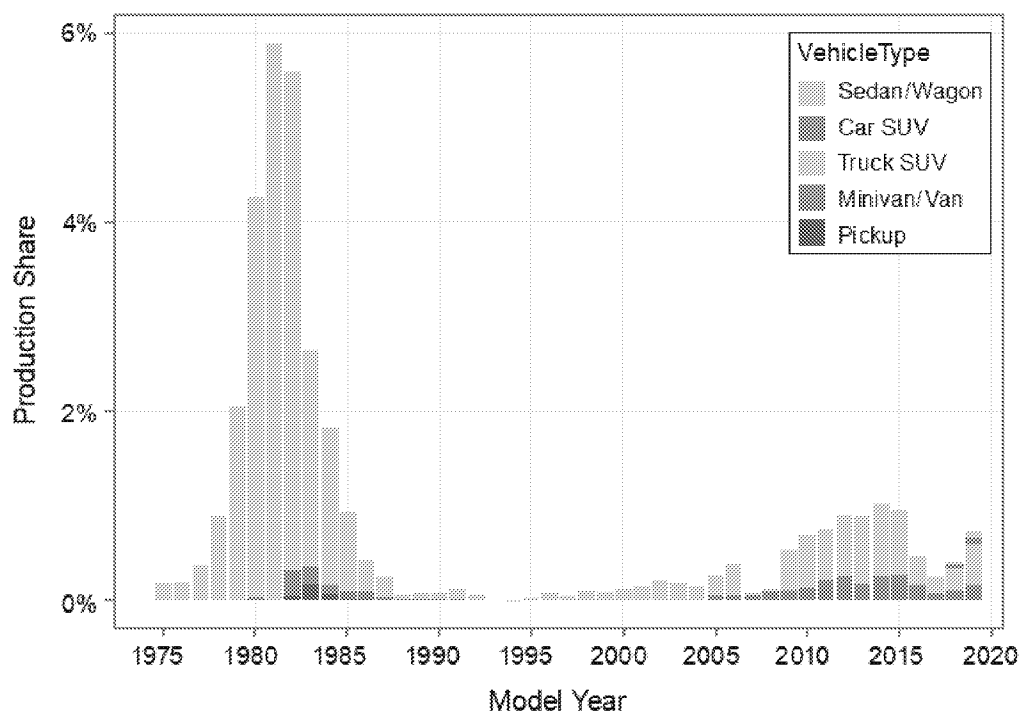
Figure 4.16. Diesel Engine Production Share by Number of Cylinders
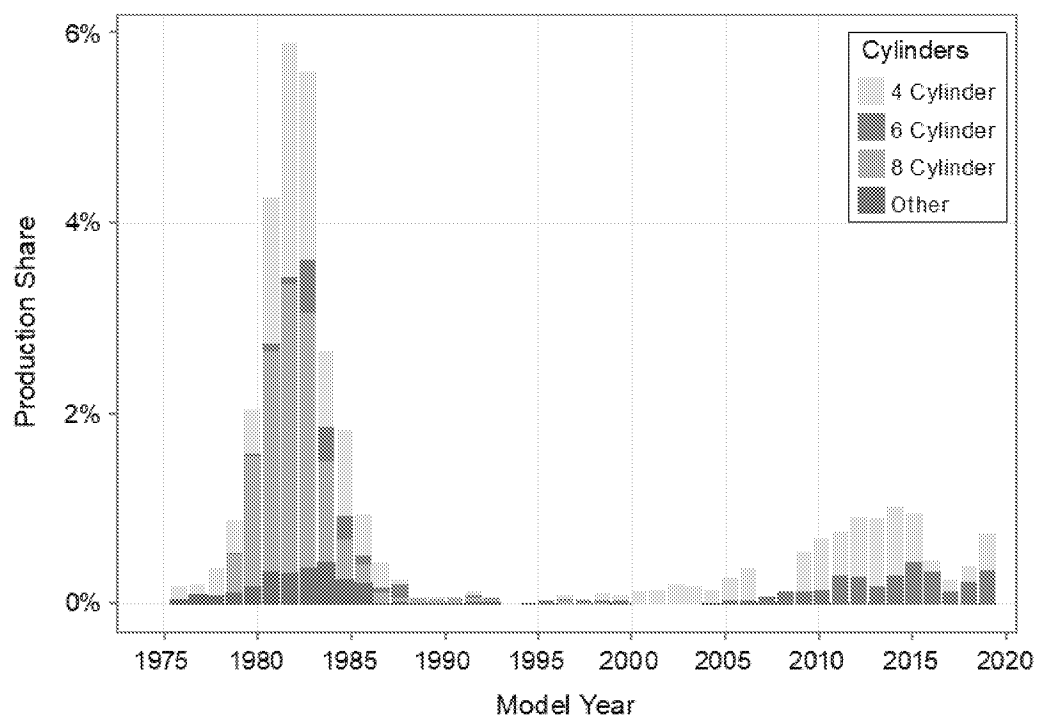
Figure 4.17. Percent Change for Specific Diesel Engine Metrics
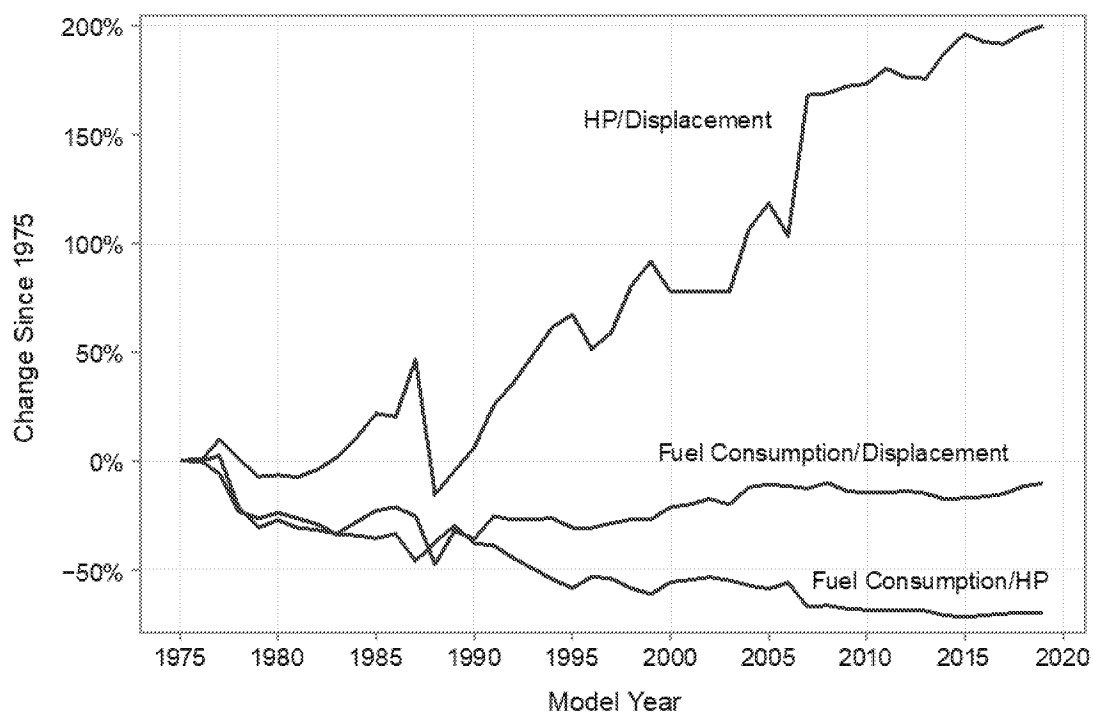
Other Engine Technologies

In addition to the engine technologies described above, there have been a small number of other technologies available in the U.S. marketplace over the years. Vehicles that operate on compressed natural gas (CNG) are one example, but there are currently no CNG vehicles available from vehicle manufacturers (aftermarket conversions are not included here). This report will continue to track all vehicles produced for sale in the U.S., and if CNG or other technologies reach widespread availability they will be included in future versions of this report.

B. Transmission and Drive Types

The vehicle transmission and driveline connect the engine to the wheels, as shown in Figure 4.1. There are two important aspects of transmissions that impact overall vehicle efficiency and fuel economy. First, as torque (rotational force) is transferred through the transmission, a small amount is lost to friction, which reduces vehicle efficiency. Second, the design of the transmission impacts how the engine is operated, and generally transmissions with more speeds offer more opportunity to operate the engine in the most efficient way possible. For example, a vehicle with an eight-speed transmission will have more flexibility in determining engine operation than a vehicle with a five-speed transmission. This can lead to reduced fuel consumption and CO_2 emissions compared to a vehicle that is identical except for the number of transmission gears.

Transmissions

Transmission designs have been rapidly evolving to increase the number of gears available and allow for both better engine operation and improved efficiency. The number of gears in new vehicles continues to increase, as does the use of continuously variable transmissions (CVTs). Figure 4.18 shows the evolution of transmission production share for cars and trucks since model year 1980.[15] For this analysis, transmissions are separated into manual transmissions, CVTs, and automatic transmissions. Automatic transmissions are further separated into those with and without lockup mechanisms, which can lock up the torque converter in an automatic transmission under certain driving conditions and improve efficiency. CVTs have also been split into hybrid and non-hybrid versions to reflect the fact that hybrid CVTs are generally very different mechanically from traditional CVTs.

Dual clutch transmissions (DCTs) are essentially automatic transmissions that operate internally much more like traditional manual transmissions. The two main advantages of DCTs are that they can shift very quickly, and they can avoid some of the internal resistance of a traditional automatic transmission by eliminating the torque converter. Currently, automaker submissions to EPA do not explicitly identify DCTs as a separate transmission category. Thus, the introduction of DCTs shows up in Figure 4.18 as a slight increase in automatic transmissions without torque converters (although some DCTs may still be reported as traditional automatic transmissions).

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[15] EPA has incomplete transmission data prior to MY 1980.

Figure 4.18. Transmission Production Share

Transmission	Lockup?	Number of Gears	Key
Automatic	No	3	A3
Semi-Automatic		4	A4
Automated Manual		5	A5*
		6	A6
		7	A7
		8	A8*
	Yes	2	L2*
		3	L3
		4	L4
		5	L5
		6	L6
		7	L7
		8	L8
		9	L9
		10	L10
Manual	—	3	M3
		4	M4
		5	M5
		6	M6
		7	M7*
Continuously Variable (non-hybrid)	—	—	CVT(n-h)
Continuously Variable (hybrid)	—	—	CVT(h)
Other	—	—	Other

*Categories A5, A8, L2, and M7 are too small to depict in the area plot.

In the early 1980s, three-speed automatic transmissions, both with and without lockup torque converters (shown as L3 and A3), were the most popular transmissions, but by model year 1985, the four-speed automatic transmission with lockup (L4) became the most popular transmission, a position it would hold for 25 years. Over 80% of all new vehicles produced in model year 1999 were equipped with an L4 transmission. After model year 1999, the production share of L4 transmissions slowly decreased as L5 and L6 transmissions were introduced into the market. Production of L5 and L6 transmissions combined passed the production of L4 transmissions in model year 2007.

Six-speed transmissions became the most popular transmission choice in model year 2010 and reached 60% of new vehicle production in model year 2013. However, the prevalence of 6-speed transmissions has since dropped quickly, to 38% in model year 2018 and to a projected 24% in model year 2019, because manufacturers are increasingly adopting transmissions with seven or more speeds and CVTs. Over the last ten years, the production share of transmissions with seven or more speeds has increased from 2% to over 36%, and the production share of CVTs (including hybrids) has increased from 8% to over 22%. While six-speed transmissions remained the most popular technology choice in model year 2018, both CVTs and eight-speed transmissions are projected to capture a higher production share than six-speed transmissions in model year 2019.

Figure 4.19 shows the average number of gears in new vehicle transmissions since model year 1980 for automatic and manual transmissions. The average number of gears in new vehicles has been steadily climbing for car, trucks, automatic transmissions, and manual transmissions. In model year 1980, automatic transmissions, on average, had fewer gears than manual transmissions. However, automatic transmissions have added gears faster than manual transmissions, and now the average automatic transmission has more gears than the average manual transmission.

Figure 4.19. Average Number of Transmission Gears for New Vehicles
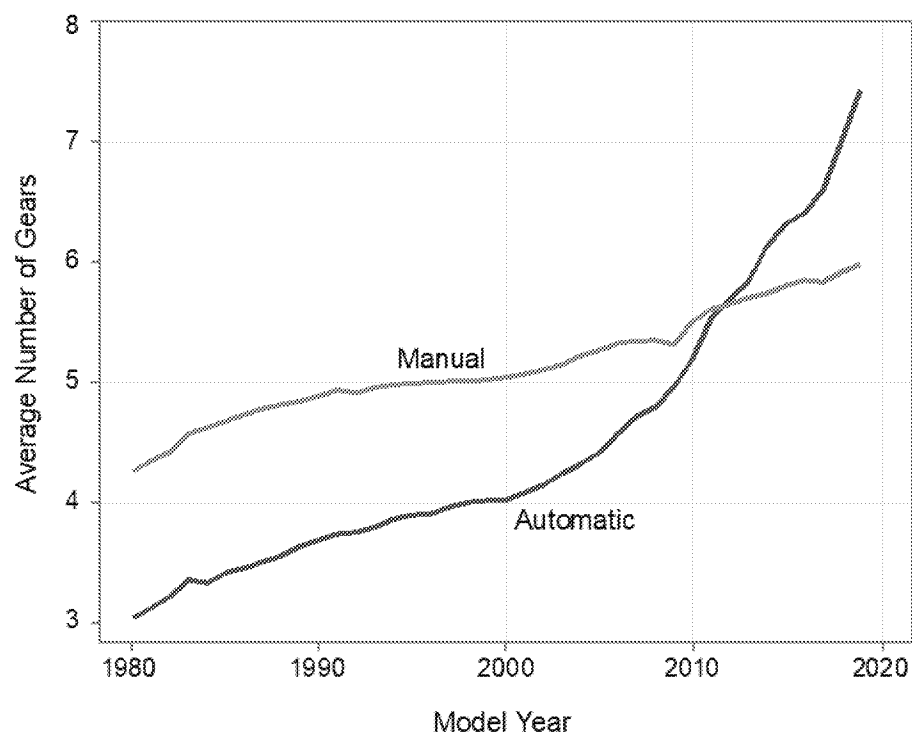
Figure 4.20. Comparison of Manual and Automatic Transmission Real-World Fuel Economy for Comparable Vehicles
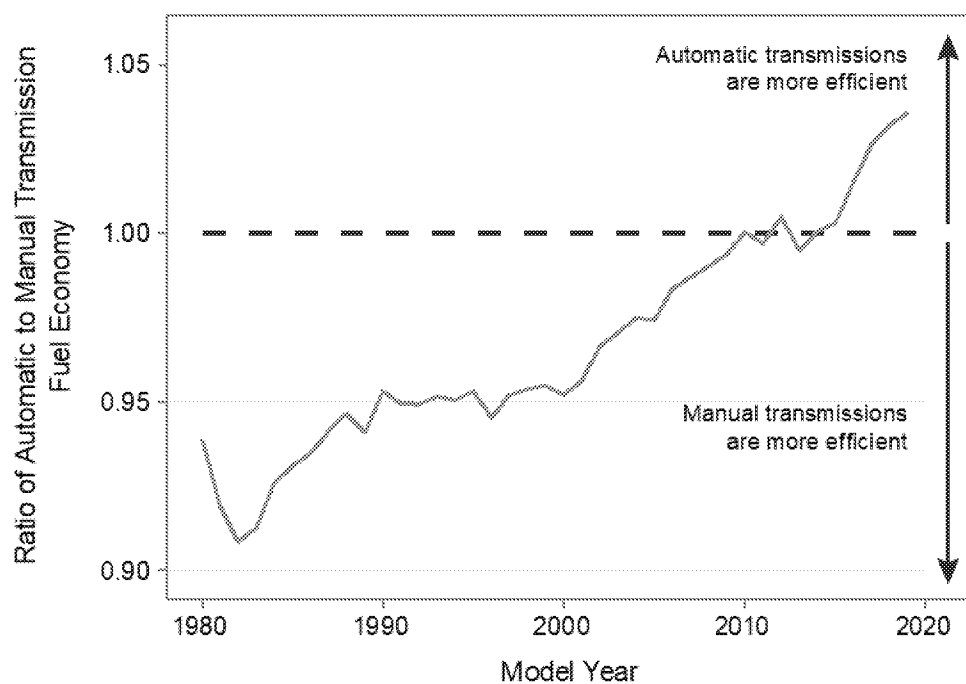
In the past, automatic transmissions have generally been less efficient than manual transmissions, largely due to inefficiencies in the automatic transmission torque converter. Figure 4.20 examines this trend over time by comparing the fuel economy of automatic and manual transmission options where both transmissions were available in one model with the same engine. Vehicles with a manual transmission were more efficient than their automatic counterparts through about 2010, but modern automatic transmissions are now more efficient. Two contributing factors to this trend are that automatic transmission design has become more efficient (using earlier lockup and other strategies), and the number of gears used in automatic transmissions has increased faster than in manual transmissions.

Since 1980, there has been a large shift away from manual transmissions. Manual transmission production peaked in model year 1980 at nearly 35% of production and has since fallen to an all-time low of 1.6% in model year 2018. Today, manual transmissions are available only in a limited number of small vehicles, sports cars, and a few pickups. The shrinking availability of manual transmissions does limit the relevance of analysis comparing current manual transmissions to automatic transmissions.

Drive Types

There has been a long and steady trend in new vehicle drive type away from rear-wheel drive vehicles towards front-wheel drive and four-wheel drive (including all-wheel drive) vehicles, as shown in Figure 4.21. In model year 1975, over 91% of new vehicles were produced with rear-wheel drive. Since then, production of rear-wheel drive vehicles has steadily declined to about 10% in model year 2018. Current production of rear-wheel drive vehicles is mostly limited to pickup trucks and some performance vehicles.

As production of rear-wheel drive vehicles declined, production of front-wheel drive vehicles increased. Front-wheel drive vehicle production was only 5% of new vehicle production in model year 1975 but began increasing until about 64% of all new vehicles in model year 1990 were front-wheel drive designs. Front-wheel drive has remained the most popular vehicle design, but the production share of front-wheel drive vehicles has been falling as production of four-wheel drive vehicles, including all-wheel drive vehicles, has been steadily growing. Four-wheel drive systems have increased from 3.3% in model year 1975 to 46% in model year 2018. If this trend continues, four-wheel drive may be the most popular drive system within a few years.

Figure 4.21. Front-, Rear-, and Four-Wheel Drive Production Share
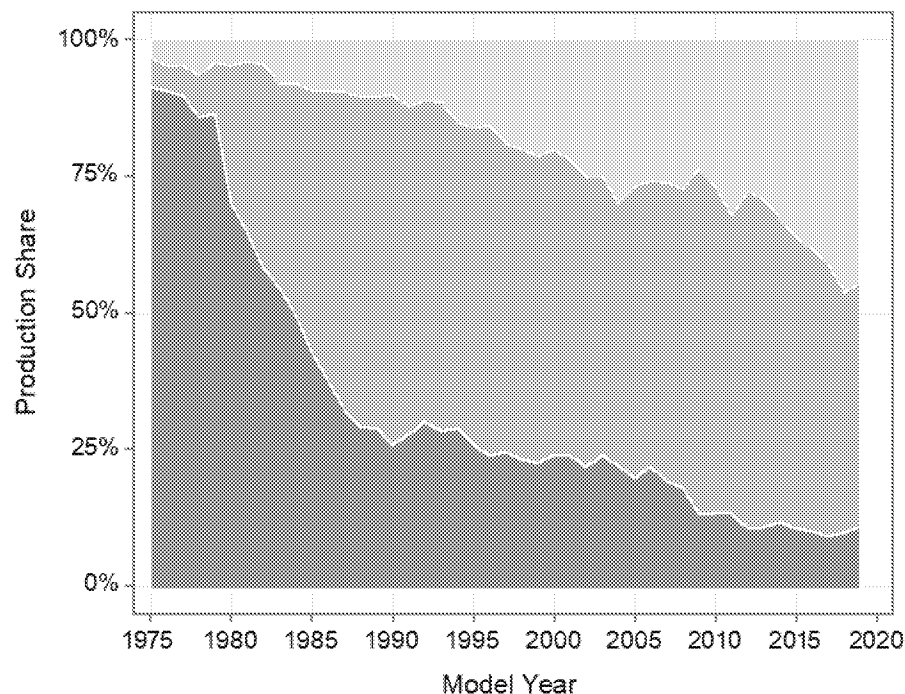
C. Technology Adoption

One additional way to evaluate the evolution of technology in the automotive industry is to focus on how technology has been adopted over time. Understanding how the industry has adopted technology can lead to a better understanding of past changes in the industry, and how emerging technology may be integrated in the future. The following analysis provides more details about how manufacturers and the overall industry have adopted new technology.

Industry-Wide Technology Adoption Since 1975

Figure 4.22 shows industry-wide adoption rates for seven technologies in passenger cars. These technologies are fuel injection (including throttle body, port, and direct injection), front-wheel drive, multi-valve engines (i.e., engines with more than two valves per cylinder), engines with variable valve timing, lockup transmissions, advanced transmissions (transmissions with six or more speeds, and CVTs), and gasoline direct injection engines. To provide a common scale, the adoption rates are plotted in terms of the number of years after the technology achieved first significant use in the industry. First significant use generally represents a production threshold of 1%, though in some cases, where full data are not available, first significant use represents a slightly higher production share.

The technology adoption pattern shown in Figure 4.22 is roughly similar for each of the seven technologies, even though they vary widely in application, complexity, and when they were initially introduced. It has taken, on average, approximately 15-20 years for new technologies to reach maximum penetration across the industry. GDI is a newer technology that has likely not reached maximum penetration across the industry but appears to be following the adoption trend of other more mature technologies. While some of these technologies may eventually be adopted in 100% of new vehicles, there may be reasons that other technologies, like front-wheel drive, will likely never be adopted in all vehicles. Adoption rates for these technologies in trucks are similar, with the exception of front-wheel drive.

The analysis for Figure 4.22 focuses on technologies that have achieved widespread use by multiple manufacturers and does not look at narrowly-adopted technologies which never achieved widespread use. One limitation to the data in this report is that EPA does not begin tracking technology production share data until after the technologies had achieved some limited market share. For example, EPA did not begin to track multi-valve engine data until model year 1986 for cars and model year 1994 for trucks, and in both cases multi-valve engines had captured about 5% market share by that time. Likewise, turbochargers

were not tracked in Trends until model year 1996 for cars and model year 2003 for trucks, and while turbochargers had less than a 1% market share in both cases at that time, it is likely that turbochargers had exceeded 1% market share in the late 1980s. Cylinder deactivation was utilized by at least one major manufacturer in the 1980s.

Figure 4.22. Industry-Wide Car Technology Penetration after First Significant Use
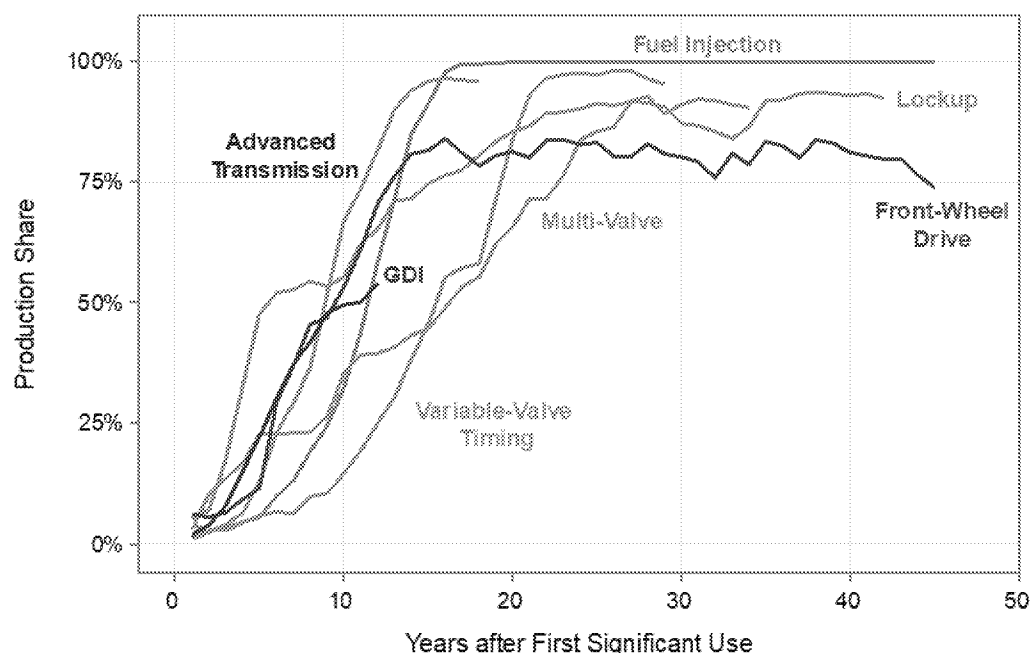
Technology Adoption by Manufacturers

The rate at which the overall industry adopts technology is determined by how quickly, and at what point in time, individual manufacturers adopt the technology. While it is important to understand the industry-wide adoption rates over time, the trends in Figure 4.22 mask the fact that not all manufacturers introduced these technologies at the same time, or at the same rate. The "sequencing" of manufacturers introducing new technologies is an important aspect of understanding the overall industry trend of technology adoption.

Figure 4.23 begins to disaggregate the industry-wide trends to examine how individual manufacturers have adopted new technologies.[16] For each technology, Figure 4.23 shows

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[16] This figure is based on available data. Some technologies may have been introduced into the market before this report began tracking them. Generally, these omissions are limited, with the exception of multi-valve

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the amount of time it took specific manufacturers to move from initial introduction to 80% penetration for each technology, as well as the same data for the overall industry. After 80% penetration, the technology is assumed to be largely incorporated into the manufacturer's fleet, and changes between 80% and 100% are not highlighted.

Of the seven technologies shown in Figure 4.23, five are now at or near full market penetration for the included manufacturers, and two are still in the process of adoption by manufacturers. The technologies shown in Figure 4.23 vary widely in terms of complexity, application, and when they were introduced into the market. For each technology, there are clearly variations between manufacturers, both in terms of when they began to adopt a technology, and the rate with which they adopted the technology. The degree of variation between the manufacturers also varies by technology.

The data for VVT (shown in Figure 4.22 and Figure 4.23), for example, show that several manufacturers adopted the technology much faster than the overall industry, which achieved 80% penetration in just over 20 years. It was not the rate of technology adoption alone, but rather the staggered implementation timeframes among manufacturers that resulted in the longer industry-wide average.

Fuel injection systems show the least amount of variation in initial adoption timing between manufacturers, which resulted in a faster adoption by the industry overall than technologies like VVT. One important driver for adoption of fuel injection was increasingly stringent emissions standards. Advanced transmissions, which have been available in small numbers for some time, have very rapidly increased market penetration in recent years and are now widely adopted. GDI engines appear to be following a similar path of quick uptake in recent years. Turbocharged engines have long been available, but the focus on turbo downsized engine packages is leading to much higher market penetration, although it is too early to tell what level of penetration they will ultimately achieve industry-wide.

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engine data for Honda. Honda had already achieved 70% penetration of multi-valve engines when this report began tracking them in 1986, so this figure does not illustrate Honda's prior trends.

Figure 4.23. Manufacturer Specific Technology Adoption over Time for Key Technologies
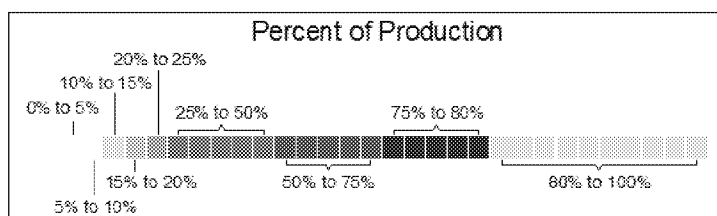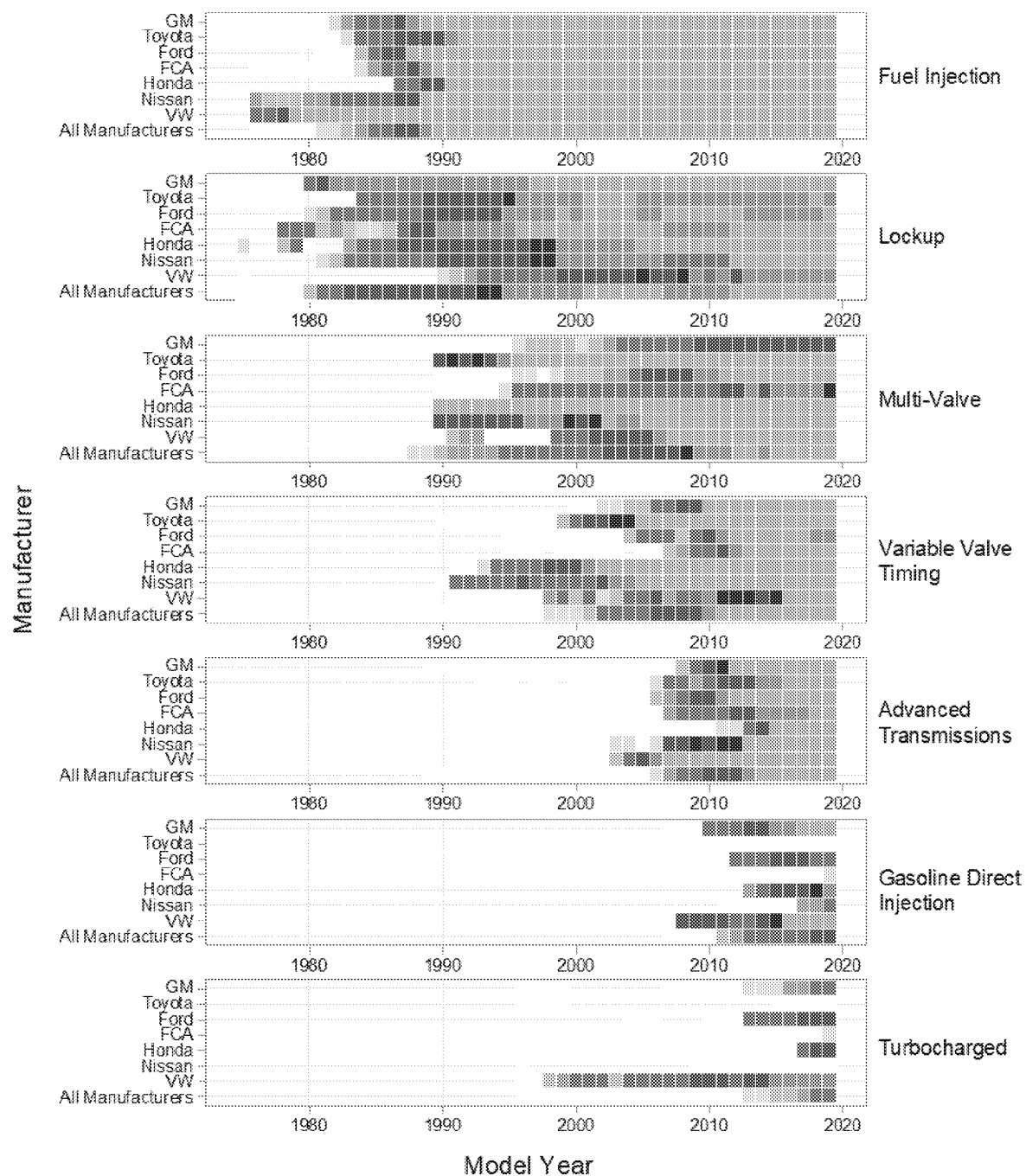
The discrepancy between manufacturer adoption rates, and the timeframe when they chose to adopt technologies, is clear in Figure 4.23 for VVT. For more detail, Figure 4.24 shows the percent penetration of VVT over time for each manufacturer (solid red line) versus the average for all manufacturers (dotted grey line) and the maximum penetration by any manufacturer (solid grey line). The largest increase in VVT penetration over any one-, three-, and five-year period for each manufacturer is shown in Figure 4.24 as green, orange, and yellow boxes.

Each manufacturer clearly followed a unique trajectory to adopt VVT. It took over 20 years for nearly all new vehicles to adopt VVT; however, it is also very clear that individual manufacturers adopted VVT across their own vehicle offerings much faster. All of the manufacturers shown in Figure 4.24 were able to adopt VVT across the vast majority of their new vehicle offerings in under 15 years, and many accomplished that feat in under ten years. As indicated by the yellow rectangles in Figure 4.24 several manufacturers increased their penetration rates of VVT by 75% or more over a five-year period. It is also important to note that every manufacturer shown adopted VVT into new vehicles at a rate faster than the overall industry-wide data would imply. The industry average represents both the rate that manufacturers adopted VVT and the effect of manufacturers adopting the technology at different times. Accordingly, the industry average shown in Figure 4.22 does not represent the average pace at which individual manufacturers adopted VVT, which is considerably faster.

VVT was first tracked in this report for cars in model year 1990 and for trucks in model year 2000. Between model year 1990 and model year 2000, there may be a small number of trucks with VVT that are not accounted for in the data. However, the first trucks with VVT produced in larger volumes (greater than 50,000 vehicles) were produced in model year 1999 and model year 2000, so the discrepancy is not enough to noticeably alter the trends in the previous figures.

Figure 4.24. VVT Adoption Details by Manufacturer
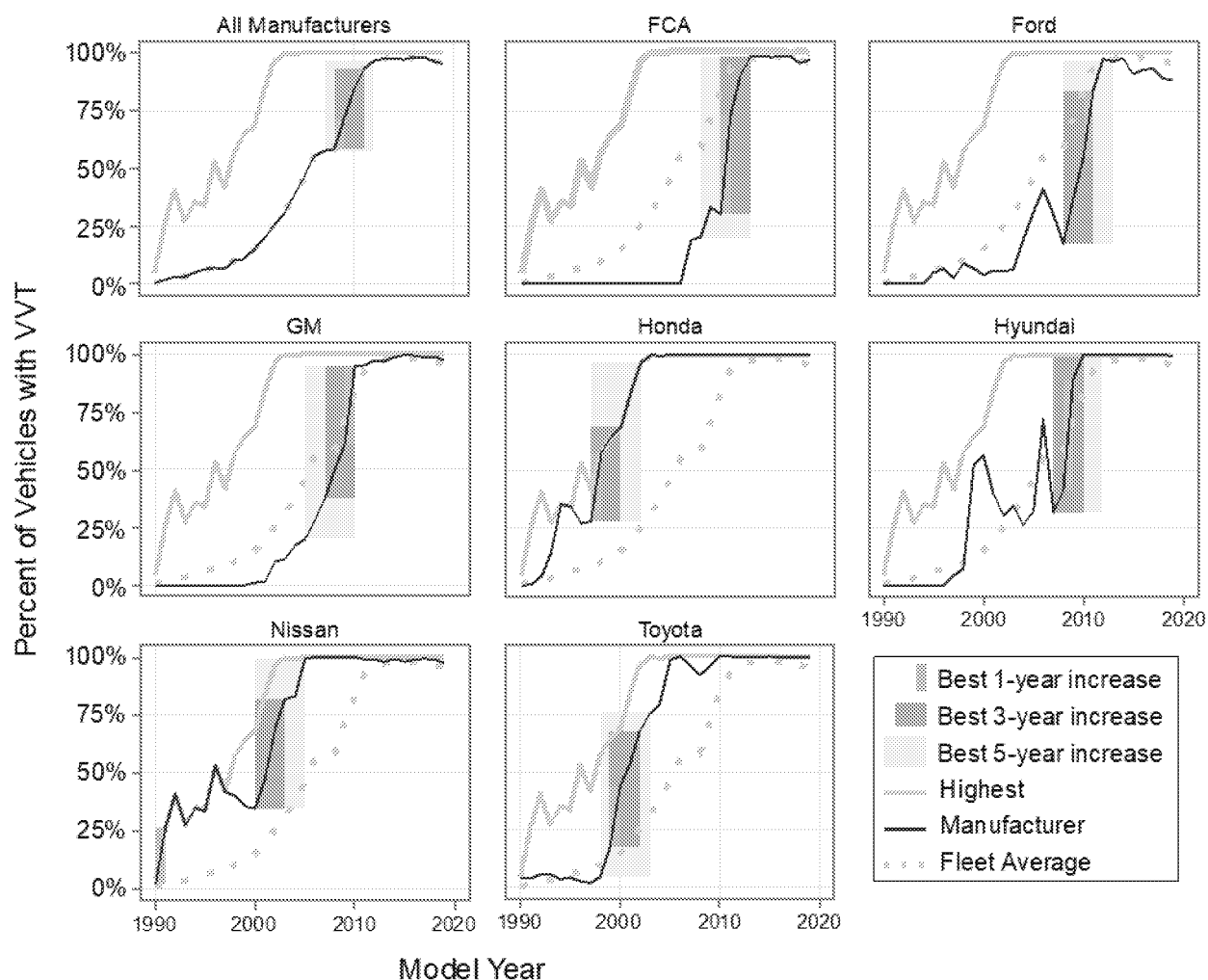
Technology Adoption in the Last Five Years

Over the last five years, engines and transmissions have continued to evolve and adopt new technologies. Figure 4.25 shows the penetration of several key technologies in model year 2013 and the projected penetration for each technology in model year 2018 vehicles. Over that five-year span, GDI is projected to increase market share by about 17%, CVTs by 17%, and transmissions with seven or more speeds by more than 35% across the entire industry. These are large changes taking place across the industry over a relatively short time. As discussed in the previous section, individual manufacturers are making technology changes at even faster rates.

Figure 4.25. Five-Year Change in Light Duty Vehicle Technology Production Share
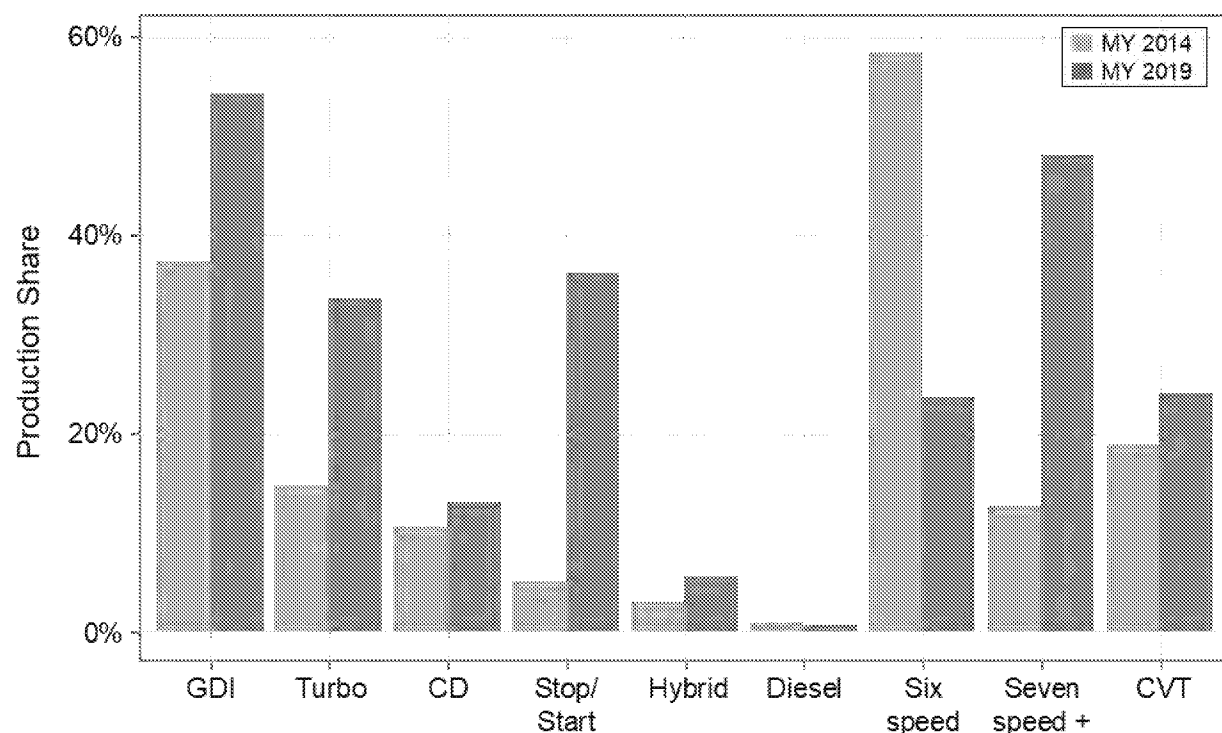
There are many factors outside the scope of this report that influence the rate and timing of when technology is adopted by individual manufacturers (e.g., price, manufacturing constraints, regulatory drivers, etc.) While no attempt is made here to identify the underlying causes, it is important to recognize that variation between manufacturers for given technologies can be masked when only the industry-wide trends are evaluated. Technology adoption by individual manufacturers is often more rapid than the overall industry trend would suggest. Manufacturers continue to adopt new technologies, and the penetration of important technologies has grown significantly over the last five years.

Table 4.1. Production Share by Engine Technologies

Model Year	Powertrain				Fuel Delivery Method						Avg. No. of Cylinders	CID	HP	Multi-Valve	VVT	CD	Turbo	Stop/Start
	Gasoline	Gasoline Hybrid	Diesel	Other	Carb	GDI	Port	TBI	EV	FCV								
1975	99.8%	-	0.2%		95.7%	-	4.1%	0.0%	-	-	6.8	293	137	-	-	-	-	-
1980	95.7%	-	4.3%		89.7%	-	5.2%	0.8%	-	-	5.6	198	104	-	-	-	-	-
1985	99.1%	-	0.9%		56.1%	-	18.2%	24.8%	-	-	5.5	189	114	-	-	-	-	-
1990	99.9%	-	0.1%		2.1%	-	70.8%	27.0%	-	-	5.4	185	135	23.1%	-	-	-	-
1995	100.0%	-	0.0%		-	-	91.6%	8.4%	-	-	5.6	196	158	35.6%	-	-	-	-
2000	99.8%	0.0%	0.1%		-	-	99.8%	0.0%	-	-	5.7	200	181	44.8%	15.0%	-	1.3%	-
2001	99.7%	0.1%	0.1%		-	-	99.9%	-	-	-	5.8	201	187	49.0%	19.6%	-	2.0%	-
2002	99.6%	0.2%	0.2%		-	-	99.8%	-	-	-	5.8	203	195	53.3%	25.3%	-	2.2%	-
2003	99.5%	0.3%	0.2%		-	-	99.8%	-	-	-	5.8	204	199	55.5%	30.6%	-	1.2%	-
2004	99.4%	0.5%	0.1%		-	-	99.9%	-	-	-	5.9	212	211	62.3%	38.5%	-	2.3%	-
2005	98.6%	1.1%	0.3%		-	-	99.7%	-	-	-	5.8	205	209	65.6%	45.8%	0.8%	1.7%	-
2006	98.1%	1.5%	0.4%		-	-	99.6%	-	-	-	5.7	204	213	71.7%	55.4%	3.6%	2.1%	-
2007	97.7%	2.2%	0.1%		-	-	99.8%	-	-	-	5.6	203	217	71.7%	57.3%	7.3%	2.5%	-
2008	97.4%	2.5%	0.1%		-	2.3%	97.6%	-	-	-	5.6	199	219	76.4%	58.2%	6.7%	3.0%	-
2009	97.2%	2.3%	0.5%		-	4.2%	95.2%	-	-	-	5.2	183	208	83.8%	71.5%	7.3%	3.3%	-
2010	95.5%	3.8%	0.7%	0.0%	-	8.3%	91.0%	-	-	0.0%	5.3	188	214	85.5%	83.8%	6.4%	3.3%	-
2011	97.0%	2.2%	0.8%	0.1%	-	15.4%	83.8%	-	0.1%	0.0%	5.4	192	230	86.4%	93.1%	9.5%	6.8%	-
2012	95.5%	3.1%	0.9%	0.4%	-	22.5%	76.5%	-	0.1%	0.0%	5.1	181	222	91.8%	96.6%	8.1%	8.4%	0.6%
2013	94.8%	3.6%	0.9%	0.7%	-	30.5%	68.3%	-	0.3%	-	5.1	176	226	92.8%	97.4%	7.7%	13.9%	2.3%
2014	95.7%	2.6%	1.0%	0.7%	-	37.4%	61.3%	-	0.3%	0.0%	5.1	180	230	89.2%	97.6%	10.6%	14.8%	5.1%
2015	95.9%	2.4%	0.9%	0.7%	-	41.9%	56.7%	-	0.5%	0.0%	5.0	177	229	91.2%	97.2%	10.5%	15.7%	7.1%
2016	96.9%	1.8%	0.5%	0.8%	-	48.0%	51.0%	-	0.5%	0.0%	5.0	174	230	92.3%	98.0%	10.4%	19.9%	9.6%
2017	96.1%	2.3%	0.3%	1.4%	-	49.7%	49.4%	-	0.6%	0.0%	5.0	174	234	92.0%	98.1%	11.9%	23.4%	17.8%
2018	95.1%	2.3%	0.4%	2.2%	-	50.2%	48.0%	-	1.4%	0.0%	5.0	172	241	91.0%	96.4%	12.5%	30.0%	29.8%
2019 (prelim)	91.0%	5.0%	0.7%	3.3%	-	54.2%	42.4%	-	2.6%	0.0%	5.0	169	244	90.5%	95.3%	13.1%	33.6%	36.3%

To explore this data in more depth, please see the report website at https://www.epa.gov/automotive-trends

Table 4.2. Production Share by Transmission Technologies

Model Year	Manual	Automatic with Lockup	Automatic without Lockup	CVT (Hybrid)	CVT (Non-Hybrid)	Other	4 Gears or Fewer	5 Gears	6 Gears	7 Gears	8 Gears	9+ Gears	CVT (Hybrid)	CVT (Non-Hybrid)	Average No. of Gears
1975	23.0%	0.2%	76.8%	-	-	-	99.0%	1.0%	-	-	-	-	-	-	-
1980	34.6%	18.1%	46.8%	-	-	0.5%	87.9%	12.1%	-	-	-	-	-	-	3.5
1985	26.5%	54.5%	19.1%	-	-	-	80.7%	19.3%	-	-	-	-	-	-	3.8
1990	22.2%	71.2%	6.5%	-	0.0%	0.0%	79.9%	20.0%	0.1%	-	-	-	-	0.0%	4.0
1995	17.9%	80.7%	1.4%	-	-	-	82.0%	17.7%	0.2%	-	-	-	-	-	4.1
2000	9.7%	89.5%	0.7%	-	0.0%	-	83.7%	15.8%	0.5%	-	-	-	-	0.0%	4.1
2001	9.0%	90.3%	0.6%	0.1%	0.0%	-	80.7%	18.5%	0.7%	-	-	-	0.1%	0.0%	4.2
2002	8.2%	91.4%	0.3%	0.1%	0.1%	-	77.1%	21.6%	1.1%	-	-	-	0.1%	0.1%	4.2
2003	8.0%	90.8%	0.1%	0.3%	0.8%	-	69.2%	28.1%	1.7%	-	-	-	0.3%	0.8%	4.3
2004	6.8%	91.8%	0.3%	0.4%	0.7%	-	63.9%	31.8%	3.0%	0.2%	-	-	0.4%	0.7%	4.4
2005	6.2%	91.5%	0.1%	1.0%	1.3%	-	56.0%	37.3%	4.1%	0.2%	-	-	1.0%	1.3%	4.5
2006	6.5%	90.6%	0.0%	1.5%	1.4%	-	47.7%	39.2%	8.8%	1.4%	-	-	1.5%	1.4%	4.6
2007	5.6%	87.1%	0.0%	2.1%	5.1%	-	40.5%	36.1%	14.4%	1.5%	0.2%	-	2.1%	5.1%	4.8
2008	5.2%	86.8%	0.2%	2.4%	5.5%	-	38.8%	31.9%	19.4%	1.8%	0.2%	-	2.4%	5.5%	4.8
2009	4.8%	85.6%	0.2%	2.1%	7.3%	-	31.2%	32.2%	24.5%	2.5%	0.1%	-	2.1%	7.3%	5.0
2010	3.8%	84.1%	1.2%	3.8%	7.2%	-	24.6%	23.5%	38.1%	2.7%	0.2%	-	3.8%	7.2%	5.2
2011	3.2%	86.5%	0.3%	2.0%	8.0%	-	14.2%	18.7%	52.3%	3.1%	1.7%	-	2.0%	8.0%	5.5
2012	3.6%	83.4%	1.1%	2.7%	9.2%	-	8.1%	18.2%	56.3%	2.8%	2.6%	-	2.7%	9.2%	5.5
2013	3.5%	80.4%	1.4%	2.9%	11.8%	-	5.4%	12.8%	60.1%	2.8%	4.1%	-	2.9%	11.8%	5.6
2014	2.8%	76.7%	1.6%	2.3%	16.6%	-	2.2%	7.8%	58.4%	3.3%	8.4%	1.1%	2.3%	16.6%	5.9
2015	2.6%	72.3%	1.4%	2.2%	21.5%	-	1.5%	4.5%	54.2%	3.1%	9.5%	3.5%	2.2%	21.5%	5.9
2016	2.2%	72.3%	2.6%	1.7%	21.2%	-	1.1%	3.0%	54.9%	2.9%	11.2%	4.1%	1.7%	21.2%	6.0
2017	2.1%	71.5%	2.6%	1.9%	21.8%	-	1.0%	2.4%	49.0%	3.4%	14.6%	5.9%	1.9%	21.8%	6.1
2018	1.6%	72.8%	3.2%	1.7%	20.6%	-	1.9%	2.0%	37.6%	3.7%	19.0%	13.5%	1.7%	20.6%	6.4
2019 (prelim)	2.0%	70.5%	3.5%	2.2%	21.9%	-	2.9%	1.2%	23.7%	2.9%	25.5%	19.6%	2.2%	21.9%	6.6

Table 4.3. Production Share by Drive Technology

Model Year	Car			Truck			All		
	Front Wheel Drive	Rear Wheel Drive	Four Wheel Drive	Front Wheel Drive	Rear Wheel Drive	Four Wheel Drive	Front Wheel Drive	Rear Wheel Drive	Four Wheel Drive
1975	6.5%	93.5%	-	-	82.8%	17.2%	5.3%	91.4%	3.3%
1980	29.7%	69.4%	0.9%	1.4%	73.6%	25.0%	25.0%	70.1%	4.9%
1985	61.1%	36.8%	2.1%	7.3%	61.4%	31.3%	47.8%	42.9%	9.3%
1990	84.0%	15.0%	1.0%	15.8%	52.4%	31.8%	63.8%	26.1%	10.1%
1995	80.1%	18.8%	1.1%	18.4%	39.3%	42.3%	57.6%	26.3%	16.2%
2000	80.4%	17.7%	2.0%	20.0%	33.8%	46.3%	55.5%	24.3%	20.2%
2001	80.3%	16.7%	3.0%	16.3%	34.8%	48.8%	53.8%	24.2%	22.0%
2002	82.9%	13.5%	3.6%	15.4%	33.1%	51.6%	52.7%	22.3%	25.0%
2003	80.9%	15.9%	3.2%	15.4%	34.1%	50.4%	50.7%	24.3%	25.0%
2004	80.2%	14.5%	5.3%	12.5%	31.0%	56.5%	47.7%	22.4%	29.8%
2005	79.2%	14.2%	6.6%	20.1%	27.7%	52.2%	53.0%	20.2%	26.8%
2006	75.9%	18.0%	6.0%	18.9%	28.0%	53.1%	51.9%	22.3%	25.8%
2007	81.0%	13.4%	5.6%	16.1%	28.4%	55.5%	54.3%	19.6%	26.1%
2008	78.8%	14.1%	7.1%	18.4%	24.8%	56.8%	54.2%	18.5%	27.3%
2009	83.5%	10.2%	6.3%	21.0%	20.5%	58.5%	62.9%	13.6%	23.5%
2010	82.5%	11.2%	6.3%	20.9%	18.0%	61.0%	59.6%	13.7%	26.7%
2011	80.1%	11.3%	8.6%	17.7%	17.3%	65.0%	53.8%	13.8%	32.4%
2012	83.8%	8.8%	7.5%	20.9%	14.8%	64.3%	61.4%	10.9%	27.7%
2013	83.0%	9.3%	7.7%	18.1%	14.5%	67.5%	59.7%	11.1%	29.1%
2014	81.3%	10.6%	8.2%	17.5%	14.2%	68.3%	55.3%	12.1%	32.6%
2015	80.4%	9.7%	9.9%	16.0%	12.6%	71.4%	52.9%	10.9%	36.1%
2016	79.8%	9.1%	11.0%	15.9%	12.2%	72.0%	51.2%	10.5%	38.3%
2017	79.8%	8.3%	11.9%	16.1%	11.0%	72.8%	49.6%	9.6%	40.8%
2018	76.6%	9.4%	14.0%	13.4%	10.9%	75.6%	43.7%	10.2%	46.1%
2019 (prelim)	74.0%	11.6%	14.5%	14.5%	11.1%	74.3%	44.1%	11.3%	44.5%

5. Manufacturer GHG Compliance

On May 7, 2010, the Environmental Protection Agency (EPA) and the National Highway Traffic Safety Administration (NHTSA) established the first phase of a National Program to reduce greenhouse gas (GHG) emissions and improve fuel economy for 2012 to 2016 model year light-duty vehicles. On October 15, 2012, EPA and NHTSA established the second phase of the joint National Program for model years 2017–2025. These standards apply to passenger cars, light-duty trucks, and medium-duty passenger vehicles. This section of the report is designed to provide as much information as possible about how the manufacturers are performing under EPA's GHG program.

The GHG program is a credit-based averaging, banking, and trading (ABT) program that evaluates every manufacturer's annual performance against increasingly stringent standards based on the vehicles each manufacturer sells. Credits represent emission reductions manufacturers achieve by reducing vehicle emissions beyond the standards. The provisions of the ABT program allow manufacturers to achieve the standards based on fleet average CO_2 emissions (i.e., the standards do not apply to individual vehicles), to bank credits or deficits for future years, and to trade credits between manufacturers. Manufacturers demonstrate compliance with the overall program by maintaining a positive or neutral credit balance.

Averaging, banking and trading have been an important part of many mobile source programs under the Clean Air Act. These provisions help manufacturers in planning and implementing the orderly phase-in of emissions reduction technology in their production, consistent with their unique redesign schedules. EPA believes the net effect of the ABT provisions is that they allow additional flexibility, encourage earlier introduction of emission reduction technologies than might otherwise occur, and do so without reducing the overall effectiveness of the program.

The GHG Program and the Compliance Process

At the end of a model year, each manufacturer must determine its compliance status with the GHG program, and report compliance data to EPA, as summarized in Figure 5.1. First, each manufacturer must determine its individual car and truck standards, based on the footprint and production volumes of the vehicles it produced in that model year.

Second, manufacturers must determine their model year performance separately for cars and trucks. For each car/truck fleet, the performance is calculated based on measured CO_2

tailpipe emissions and the impact of flexibilities that manufacturers may qualify for and use. These flexibilities include optional credits for improved air-conditioning systems, emission-reducing technologies that are not accounted for on standard EPA tests, alternative fuel vehicles, and alternate standards for small volume manufacturers.

Figure 5.1. GHG Program Compliance Process

```
┌─────────────────┐   ┌──────────────────────┐
│   Calculate     │   │  Measure Model Year  │
│  Model Year     │   │     Performance      │
│   Standards     │   │ - Tailpipe Emissions │
│                 │   │    - Flexibilities   │
└────────┬────────┘   └──────────┬───────────┘
         │                       │
         ▼                       ▼
┌──────────────────────────────────────────────┐
│           Update Credit Balance               │
│  - Model Year Standards vs Performance        │
│           - Credit Transactions               │
│            - Credit Expirations               │
└──────────────────────────────────────────────┘
```

Credit/Deficit Balance Carried to Next Model Year (ABT provisions)

Determine Compliance Status
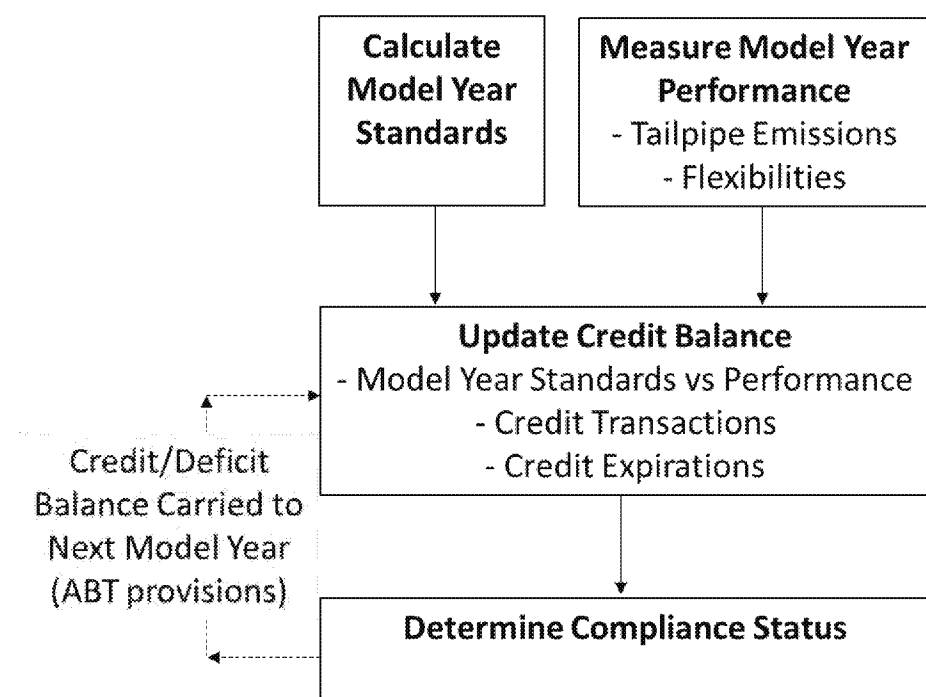
After determining their standards and performance, manufacturers must determine an updated credit balance. Each manufacturer must compare its car and truck fleet's performance to its respective car and truck fleet standards to determine a credit surplus or shortfall. The model year credit surplus or shortfall for each fleet, any prior credit balance, and the impact of any credit transactions or expiring credits combine to determine the manufacturer's updated credit balance.

Finally, manufacturers must determine their compliance status. If a manufacturer ends the model year with a positive credit balance, it is in compliance with the GHG program, and its credit balance will be carried forward to the next model year. If a manufacturer ends the model year with a negative credit balance that it is unable to offset, it is considered to have a credit deficit. A deficit does not immediately result in non-compliance with EPA's GHG program, but manufacturers must offset the deficit within three years to avoid non-compliance. For example, a manufacturer with a deficit remaining from model year 2015

after the 2018 model year would be considered out of compliance with the 2015 model year standards. Manufacturers may not carry forward any credits unless all deficits have been offset.

GHG Compliance and Credit Data

This section includes final compliance data for model years 2009 to 2018. The data in this report reflect all credits and transactions reported to EPA prior to September 30th, 2019. However, credit transactions can occur between manufacturers at any time. Any additional credit requests or transactions will be reflected in next year's report. This report includes the most up-to-date data for all model years, and therefore supersedes all previous reports.

The GHG program uses two different metrics to measure CO_2 emissions, per vehicle emission rates measured in grams per mile (g/mi), and total vehicle lifetime emissions measured in megagrams (Mg). Manufacturer standards, tailpipe CO_2 emissions, and most annual credits and flexibilities described in this report are discussed as per vehicle emission rates in g/mi.

However, the total credit balance of manufacturers is calculated in Mg to account for the number of vehicles produced and the expected lifetime use of those vehicles, in addition to manufacturer performance compared to their standards (see

> **How to Calculate Vehicle Lifetime Emissions from a Per-Mile Emission Rate**
>
> In the GHG Program, vehicle lifetime emissions are measured in megagrams (Mg) of CO_2. One megagram is equal to 1,000 kilograms, and is also known as a metric ton. Emissions in Mg are determined from gram per mile (g/mi) emission rates, production volume, and expected lifetime miles. To calculate total Mg of credits the following equation is used:
>
> Credits [Mg] = (CO_2 x VMT x Production) / 1,000,000
>
> "CO_2" represents a credit in g/mi. "VMT" represents the total lifetime miles, which is specified in the regulations as 195,264 miles for cars and 225,865 for trucks. "Production" represents the production volume to which the CO_2 credit applies. To calculate g/mi from Mg:
>
> CO_2 [g/mi] = (Credits[Mg] x 1,000,000) / (VMT x Production)
>
> When using these equations to calculate values for cars and trucks in aggregate, use a production weighted average of the car and truck VMT values. For the 2018 model year, the weighted VMT is 210,285 miles.

inset "How to Calculate Vehicle Lifetime Emissions from a Per-Mile Emission Rate"). Any discussion of manufacturer total credit balances, credit transactions, and compliance will be in terms of megagrams or teragrams (Tg) of credits (1 teragram is equal to 1 million megagrams).

Unlike the previous sections, the tailpipe CO_2 emission data presented in this section are compliance data, based on EPA's City and Highway test procedures (referred to as the "2-

cycle" tests). These values should not be compared to the estimated real-world data throughout the rest of this report. For a detailed discussion of the difference between real-world and compliance data, see Appendix C.

In addition, four small volume manufacturers have been excluded from this section of the report. Aston Martin, Ferrari, Lotus, and McLaren have applied for alternative standards available to small manufacturers, and decisions on these applications remain pending. A future edition of this report will include data from these companies once EPA makes a final determination on their requests. As a result, the total fleetwide production volume reported in this section will be slightly lower than values reported elsewhere in this report.

To download the data presented in this section, and any additional data EPA may make available, please see the report website: https://www.epa.gov/automotive-trends.

A.   Footprint-Based CO_2 Standards

At the end of each model year, manufacturers are required to calculate unique CO_2 standards for each fleet (cars and trucks) as specified in the regulations. As described previously, these standards are specific to each manufacturer's car and truck fleet based on the number of vehicles produced and the vehicle footprints within each fleet. Manufacturers must calculate new standards each year as the footprint targets become more stringent, and as their footprint distribution and production change. See Section 3 for a discussion of the trends in footprint across the industry and the definitions of "car" and "truck" under the regulations.

The regulations define footprint "curves" that provide a CO_2 emissions target for every vehicle footprint, as shown in Figure 5.2. For example, a car with a footprint of 46.5 square feet in model year 2018 (the average car footprint) has a compliance CO_2 target of 208.8 g/mi. This is a target and not a standard, as there are no footprint-based CO_2 emissions requirements for individual vehicles. The unique CO_2 standards for each manufacturer's car and truck fleets are production-weighted averages of the CO_2 target values, as determined from the curves, for all the unique footprint values of the vehicles within that fleet. This is an element of the "averaging" approach of the ABT program. Using one production-weighted average to define a single fleet standard allows for some individual vehicles to be above that standard, relying on other vehicles below the fleet standard to achieve compliance.

The footprint curves for the 2012 and 2018 model years are shown in Figure 5.2. The targets have gradually decreased (become more stringent) from 2012 to the current 2018

levels, as defined in the regulations. Larger vehicles have higher targets, although the increases are capped beyond a certain footprint size (i.e., the curves become flat). Trucks have higher targets than cars of the same footprint in the same model year. Trends in the overall average footprint value and vehicle type mix, as discussed in Section 3, are thus important because of the direct impact on the annual GHG standards.

Figure 5.2. 2012–2018 Model Year CO_2 Footprint Target Curves
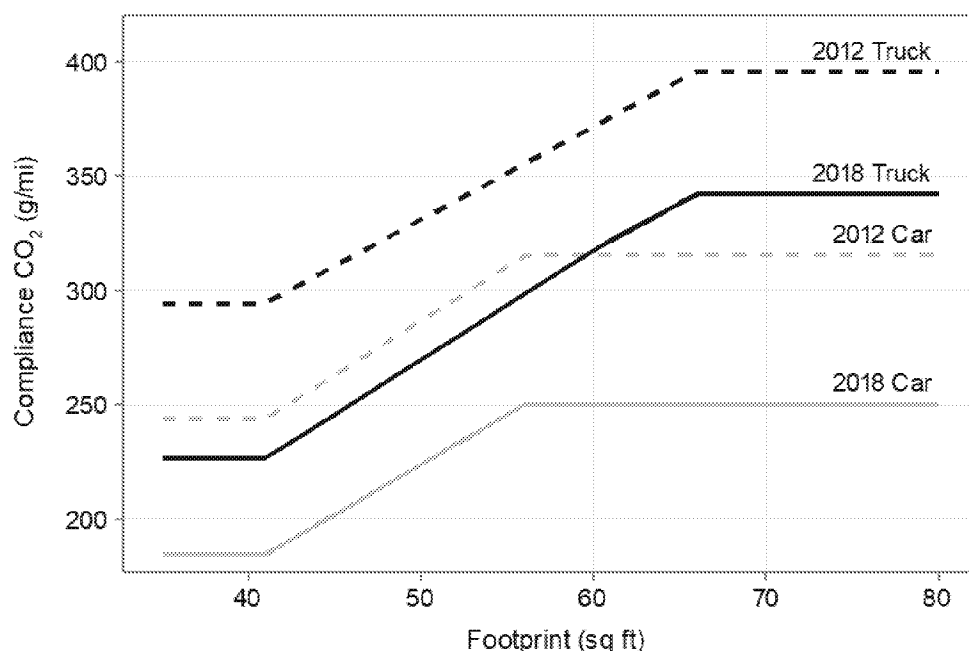
In model year 2018, the average car and truck footprints were about the same as the previous year, at 46.5 and 53.9 square feet, respectively. The industry did continue to move more towards trucks, as trucks increased their market share considerably by five percentage points. The more stringent model year 2018 targets resulted in a reduction of the car standard by 10 g/mi and of the truck standard by 9 g/mi. The increase in stringency for trucks in 2018 was considerably more than the 1 g/mi change seen from model year 2016 to model year 2017. While there is no combined car and truck standard for regulatory purposes, this report will often calculate one to provide an overall view of the industry and to allow comparison across manufacturers. Overall, the effective combined car and truck standard decreased by 6 g/mi from 2017 to 2018.

Jaguar Land Rover and Volvo opted to continue to meet the 2016 model year standards in 2018 under special provisions for intermediate volume manufacturers (less than 50,000 vehicles produced per year). These provisions allow qualifying manufacturers to use an alternative compliance schedule that allows them to meet the 2016 model year standards

in the 2017 and 2018 model years, delay meeting the 2018–2020 standards by one model year, and finally align with the primary standards and other manufacturers in the 2021 model year. Thus, the standards shown in Table 5.1 for these two manufacturers reflect the less stringent 2016 model year footprint target curves rather than the 2018 curves.

Table 5.1. Manufacturer Footprint and Standards for Model Year 2018

Manufacturer	Footprint (ft²)			Standards (g/mi)		
	Car	Truck	All	Car	Truck	All
BMW	47.3	51.1	48.3	212	275	231
BYD Motors	47.9	-	47.9	215	-	215
FCA	48.9	52.8	52.0	220	282	271
Ford	46.6	59.9	55.3	210	308	278
GM	46.4	59.2	54.4	209	308	275
Honda	46.3	49.4	47.4	208	267	232
Hyundai	46.5	49.2	46.6	209	266	211
Jaguar Land Rover	49.1	51.0	50.8	244	287	283
Kia	46.2	49.5	46.9	207	267	221
Mazda	45.6	47.9	46.5	206	260	227
Mercedes	48.3	51.3	49.6	217	276	244
Mitsubishi	41.5	44.2	42.9	192	242	221
Nissan	46.0	51.7	47.8	207	277	232
Subaru	44.9	45.0	45.0	202	246	237
Tesla	50.3	54.8	50.4	225	292	228
Toyota	46.1	51.6	48.8	207	275	243
Volkswagen	45.9	50.5	48.4	206	272	245
Volvo	50.7	52.1	51.8	252	292	283
All Manufacturers	**46.5**	**53.9**	**50.4**	**209**	**286**	**252**

B. Model Year Performance

After determining their standards for a given model year, manufacturers must determine the CO_2 emissions performance for their car and truck fleets. In this report, we use the concept of a fleet's "performance" as a useful way to explain how manufacturers' fleets are performing in comparison to the standards (it is not explicitly part of the regulations). Model year performance is defined as the average production-weighted tailpipe CO_2 emissions of that fleet, adjusted by the net impact of all applicable flexibilities.

Tailpipe CO_2 Emissions

The starting point for determining compliance for each manufacturer is its "2-cycle" tailpipe GHG emissions value. All manufacturers are required to test their vehicles on the Federal Test Procedure (known as the "City" test) and the Highway Fuel Economy Test (the "Highway" test). Results from these two tests are combined by weighting the City test by 55% and the Highway test by 45%, to achieve a single combined CO_2 value for each vehicle model. Manufacturers then calculate a sales-weighted average of all the combined city/highway values for each car and truck fleet. This represents the measured tailpipe CO_2 emissions of a fleet without the application of any additional credits or incentives. As discussed previously in this report, 2-cycle tailpipe CO_2 emissions should only be used in the context of the compliance regulations and are not the same as and should not be compared to the estimated real-world values reported in Sections 1–4.

Figure 5.3 shows the 2-cycle tailpipe emissions reported by each manufacturer for the 2012 and 2018 model years, for all vehicles and for car and truck fleets. Companies that produce solely electric vehicles (Tesla and BYD) are excluded from the figure because they produce zero tailpipe emissions on the 2-cycle test procedures.

Every manufacturer except Ford and Volkswagen reduced fleetwide tailpipe GHG emissions since the program took effect in model year 2012. Volkswagen is a good example of how changes in the fleet mix can impact overall emissions; while Volkswagen has reduced emissions in both their car and truck fleets since 2012, the broader shift to making fewer cars and more trucks has caused overall fleet emissions to increase. Compliance is assessed on a fleet-specific basis, and most manufacturers have reduced emissions within their car and truck fleets, some considerably, leading to reductions of 31 and 49 g/mi in the car and truck fleets, respectively, since model year 2012.

Figure 5.3. Changes in "2-Cycle" Tailpipe CO_2 Emissions, Model Year 2012 to 2018 (g/mi)

	All	Car	Truck
Tesla	● 0	● 0	● 0
BYD	● 0	● 0	

	All	Car	Truck
Mitsubishi	229 ← 267	197 ← 262	252 ← 283
Honda	229 ← 266	203 ← 237	269 ← 320
Mazda	239 ← 263	225 ← 241	261 ← 324
Subaru	240 ← 282	244 ← 257	239 ← 296
Hyundai	245 ← 249	241 ← 243	312 → 340
Kia	253 ← 266	233 ← 258	320 ← 324
Nissan	257 ← 295	225 ← 258	313 ← 382
BMW	268 ← 302	253 ← 277	304 ← 363
Volvo	272 ← 311	247 ← 297	279 ← 343
Toyota	273 ● 273	216 ← 221	324 ← 354
VW	281 ► 282	257 ← 274	300 ← 330
Mercedes	299 ← 343	269 ← 316	335 ← 393
GM	309 ← 331	234 ← 283	348 ← 397
Ford	315 ● 315	253 ← 261	343 ← 385
Jaguar Land Rover	317 ← 426	269 ← 376	322 ← 439
FCA	327 ← 357	300 ► 302	332 ← 384
All Manufacturers	280 ← 302	228 ← 259	320 ← 369

Compared to the first year of the program, Jaguar Land Rover leads manufacturers in both the overall reduction in 2-cycle CO_2 emissions (109 g/mi) and the percentage reduction (26%). Eight manufacturers have reduced tailpipe CO_2 emissions by 10–15%, while the remainder produced single digit percentage reductions since the first year of the program. Overall, tailpipe CO_2 emissions of the entire fleet have been reduced by 22 g/mi, or about 7%, since the 2012 model year. These tailpipe values should not be directly compared to the manufacturer's standards presented in Table 5.1, as the standards were created taking into consideration the optional credit opportunities available to manufacturers, and final fleet performance values will take these credits into account.

Credits for Producing Alternative Fuel Vehicles

EPA's GHG program provides several incentives for dedicated and dual fuel alternative fuel vehicles. Dedicated alternative fuel vehicles run exclusively on an alternative fuel (e.g., compressed natural gas (CNG), electricity). Dual fuel vehicles can run both on an alternative fuel and on a conventional fuel; the most common is the gasoline-ethanol flexible fuel vehicle (FFV), which can run on E85 (85% ethanol and 15% gasoline), or on conventional gasoline. Dual fuel vehicles also include those that use CNG and gasoline, or electricity and gasoline. This section separately describes three categories of alternative fuel vehicles: advanced technology vehicles using electricity or hydrogen fuel cells, CNG vehicle, and FFVs.

Advanced Technology Vehicles

Advanced technology vehicle incentives apply to electric vehicles (EVs), plug-in hybrid electric vehicles (PHEVs), and fuel cell vehicles (FCVs). For the 2012–2016 model years, these incentives allowed EVs and FCVs to use zero g/mi to characterize their emissions, and PHEVs to use a zero g/mi value for the portion of operation attributed to the use of grid electricity (i.e., only emissions from the portion of operation attributed to the gasoline engine are counted). Use of the zero g/mi option was limited to the first 200,000 qualified vehicles produced by a manufacturer in the 2012–2016 model years. No manufacturer reached this limit. In the 2017–2021 model years, manufacturers may continue to use zero g/mi for these vehicles, without any limits. This incentive is reflected in the 2-cycle emissions values shown previously.

For model years 2017–2021, there are also temporary incentive "multipliers" for EVs, PHEVs, FCVs, and CNG vehicles. Multipliers allow manufacturers to count these vehicles as more than one vehicle in their fleet average emissions calculations. For example, the 2.0

multiplier for 2018 model year EVs allows a manufacturer to count every EV produced as two EVs, thus doubling the fleet emissions impact of their EV production. The multipliers established by rulemaking are shown in Table 5.2.

Table 5.2. Production Multipliers by Model Year

Model Year	Electric Vehicles and Fuel Cell Vehicles	Plug-In Hybrid Electric Vehicles, Dedicated Natural Gas Vehicles, and Dual-Fuel Natural Gas Vehicles
2017	2.0	1.6
2018	2.0	1.6
2019	2.0	1.6
2020	1.75	1.45
2021	1.5	1.3

Figure 5.4 shows the model year 2018 production volume of vehicles qualifying for the zero g/mi incentive. More than 350,000 EVs, PHEVs, and FCVs were produced in the 2018 model year; 37% were PHEVs with a multiplier of 1.6, and the remaining 63% were EVs and FCVs with a multiplier of 2.0. Tesla increased sales substantially in the 2018 model year, accounting for 86% of the EVs produced. Since the 2012 model year, production of advanced technology vehicles has increased almost tenfold, with virtually every manufacturer offering something in this category of vehicles. Most are EVs and PHEVs; only a very small fraction are FCVs. Figure 4.13 in the previous section shows the overall trends in EVs, PHEVs, and FCVs.

EPA and NHTSA received a joint petition from the Alliance of Automobile Manufacturers and the Association of Global Automakers on June 20, 2016 regarding aspects of the CAFE and GHG programs. Item 8 of the petition, titled "Correct the Multiplier for BEVs, PHEVs, FCVs, and CNGs," notes that "the equation through which the number of earned credits is calculated is inaccurately stated in the regulations" and that credits would be inadvertently lost due to the error. Agreeing with the automaker petition, EPA proposed to modify the regulations to correctly calculate the multiplier-based credits in a notice of proposed rulemaking (NPRM) published on October 1, 2018.

EPA will not prejudge the outcome of an ongoing regulatory process, therefore this report is unable to include official multiplier-based credits for manufacturers until the rulemaking is completed. These credits benefit almost every manufacturer; thus, a true picture of compliance is not possible without representing the impacts of the multipliers. For the purposes of this report, and to represent the multiplier-based credits fairly and

consistently across manufacturers, we include a preliminary determination of multiplier-based credits for each manufacturer with qualifying vehicles. These preliminary credits were determined using the methodology proposed in the October 2018 NPRM and should be viewed only as unofficial estimates. Official values will be included in a future edition of this report after regulations are finalized.

Figure 5.4. Model Year 2018 Production of EVs, PHEVs, and FCVs
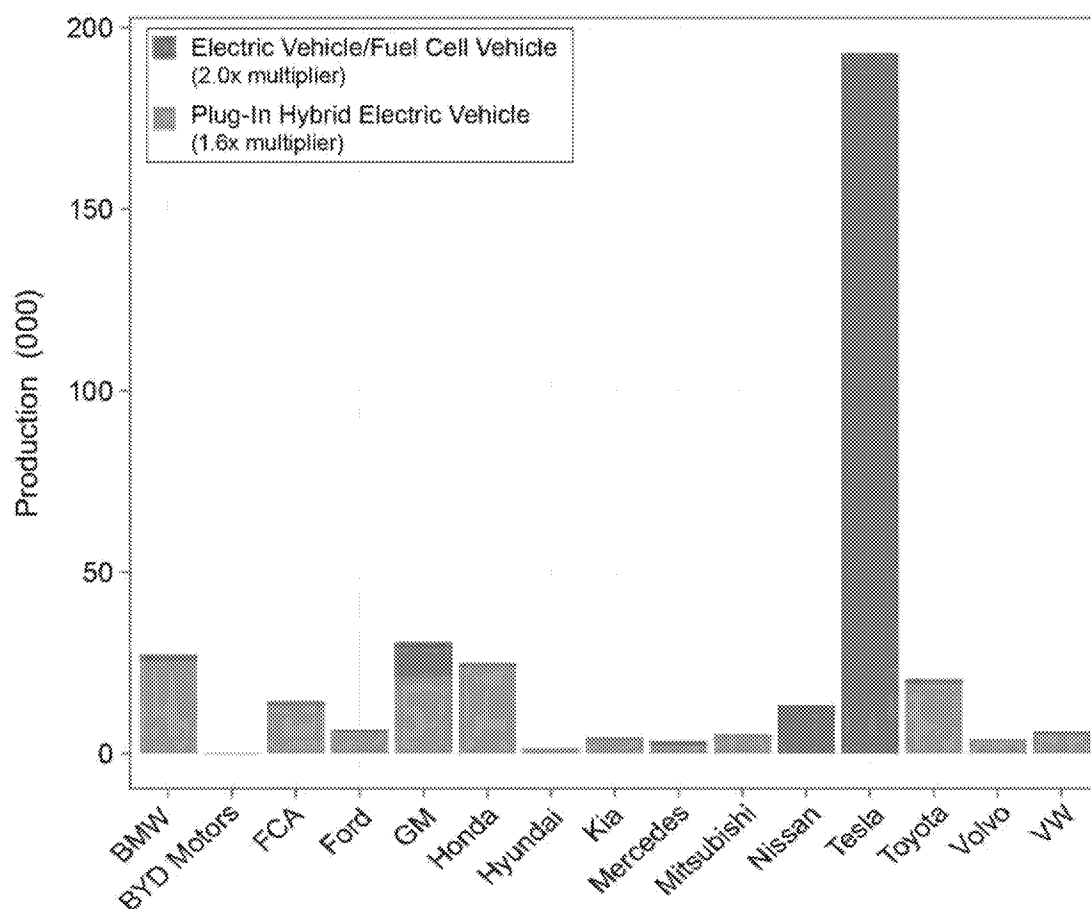
The multiplier-based credits are dependent on the type of advanced technology vehicle and the proportion of a manufacturer's fleet made up of qualifying vehicles. Figure 5.5 shows the estimated multiplier-based credits, in g/mi, for each manufacturer. Excluding Tesla, which makes only electric vehicles, BMW produced the most electrified vehicles in terms of percentage of total production, and GM led total production. PHEVs made up 7% of BMW's fleet in model year 2018 and gave them a benefit of 6.9 g/mi (i.e., effectively reducing their fleet performance by 6.9 g/mi). Volvo had the second largest benefit from advanced technology vehicles, getting a reduction of 4.5 g/mi from the 4% of their fleet that

was PHEVs. The companies that make solely EVs—BYD and Tesla—are shown separately in Figure 5.5 because of the disproportionate credit values for these companies.

Figure 5.5. Model Year 2018 Advanced Technology Credits by Manufacturer
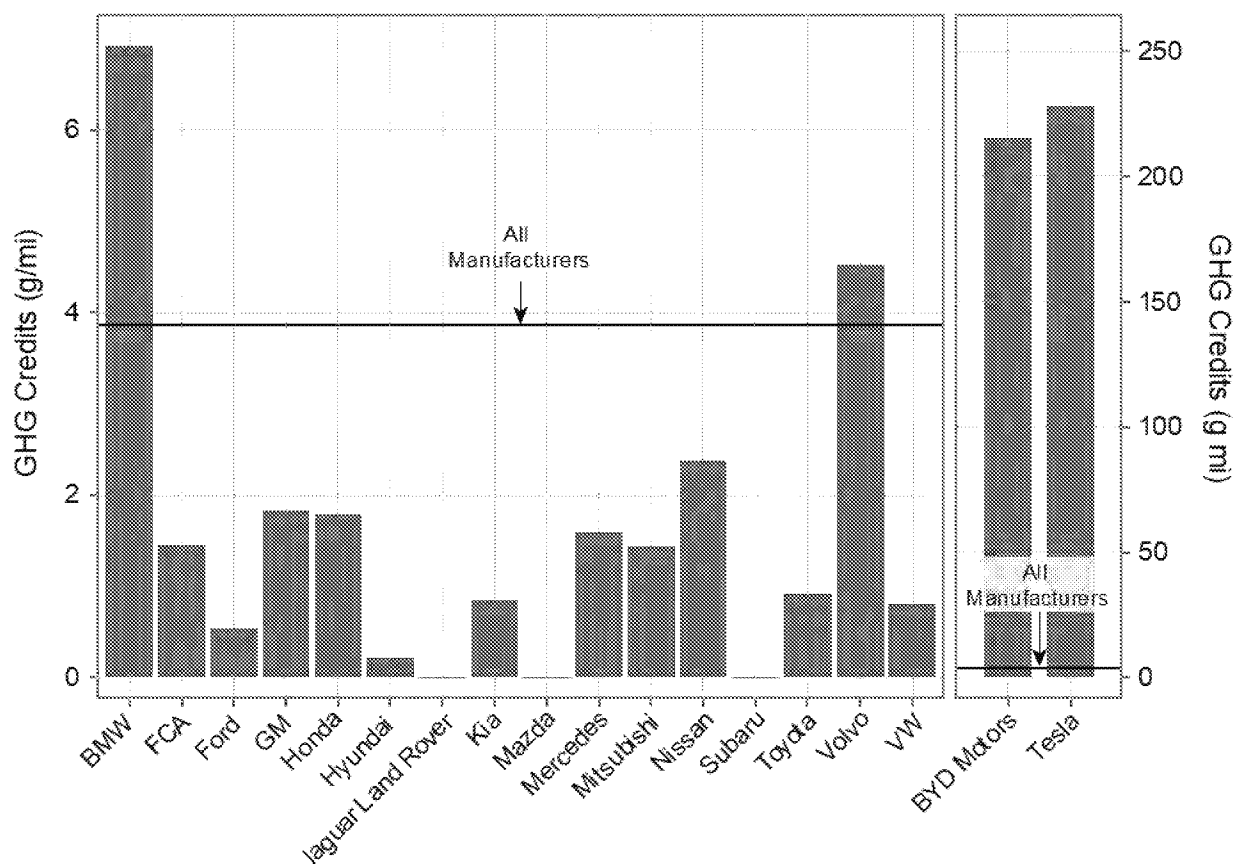
Compressed Natural Gas Vehicles

There were no CNG vehicles subject to the GHG standards in the 2018 model year. The Honda Civic CNG was the only CNG vehicle produced for general purchase by consumers during the first phase of EPA's GHG program, and it was only available in the 2012–2014 model years. In the 2015 and 2016 model years, Quantum Technologies offered a dual fuel (CNG and gasoline) version of GM's Chevrolet Impala through an agreement with GM, but none were produced in the 2017 or 2018 model years.

Gasoline-Ethanol Flexible Fuel Vehicles

For the 2012 to 2015 model years, FFVs could earn GHG credits corresponding to the fuel economy credits under CAFE. For both programs, it was assumed that FFVs operated half

of the time on each fuel. The GHG credits were based on the arithmetic average of alternative fuel and conventional fuel CO_2 emissions. Further, to fully align the GHG credit with the CAFE program, the CO_2 emissions measurement on the alternative fuel was multiplied by 0.15. The 0.15 factor was used because, under the CAFE program's implementing statutes, a gallon of alternative fuel is deemed to contain 0.15 gallons of gasoline fuel, and the E85 fuel economy is divided by 0.15 before being averaged with the gasoline fuel economy.

Starting in model year 2016, GHG compliance values for FFVs are based on the actual emissions performance of the FFV on each fuel, weighted by EPA's assessment of the actual use of these fuels in FFVs. A 2014 guidance letter defined an "F factor" of 0.14 to use when weighting E85 and gasoline CO_2 emissions for the 2016–2018 model years FFVs; this reflects EPA's estimate that FFVs would be operating 14% of the time on E85. This approach is comparable to the "utility factor" method used to weight gasoline and electricity for PHEVs, which projects the percentage of miles that a PHEV will drive using electricity based on how many miles a fully-charged PHEV can drive using grid electricity.

FFVs can still represent a CO_2 emissions benefit, and can help to lower the emissions of a manufacturer's fleet, but the overall impact is significantly diminished. Because the FFV values now incorporate the slightly lower CO_2 emissions when operating on E85 (typically 1–3% lower than on gasoline), and a realistic rate of E85 fuel use, the benefit from FFVs is no longer of the same magnitude that it was through the 2015 model year. Thus, we are no longer illustrating a g/mi benefit to manufacturers specific to producing FFVs. The impact of E85, a lower-GHG fuel than gasoline, is inseparable from, and built into, the 2-cycle emissions described earlier.

Most manufacturers focused their FFV production in the truck segment, with trucks making up more than 80% of all FFV production in the 2018 model year. FFV production continued the decline that started after model year 2014, dropping 20% relative to model year 2017 and reaching a low since the start of the program in model year 2012. Total FFV production in model year 2018 was down by almost 70% relative to model year 2014, the peak year for FFV production. FFV production is shown in Figure 5.6. The credit impact of those FFV credits is shown in Figure 5.7.

Figure 5.6. Production of FFVs, Model Year 2012–2018
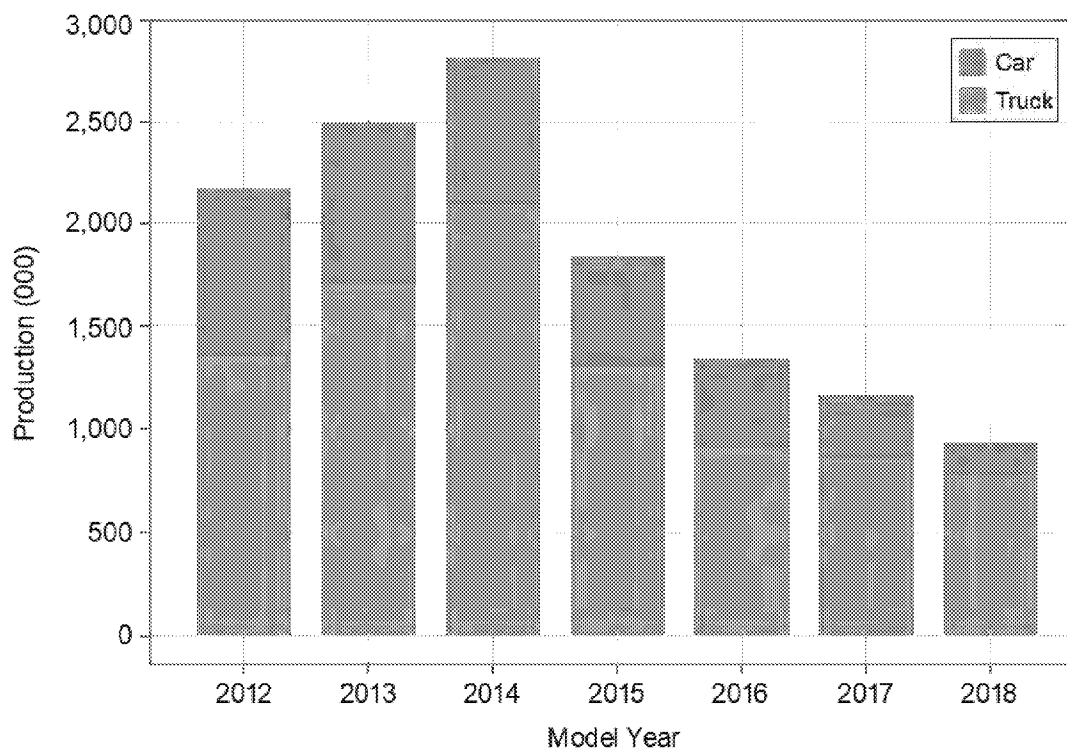
Figure 5.7. FFV Credits by Model Year
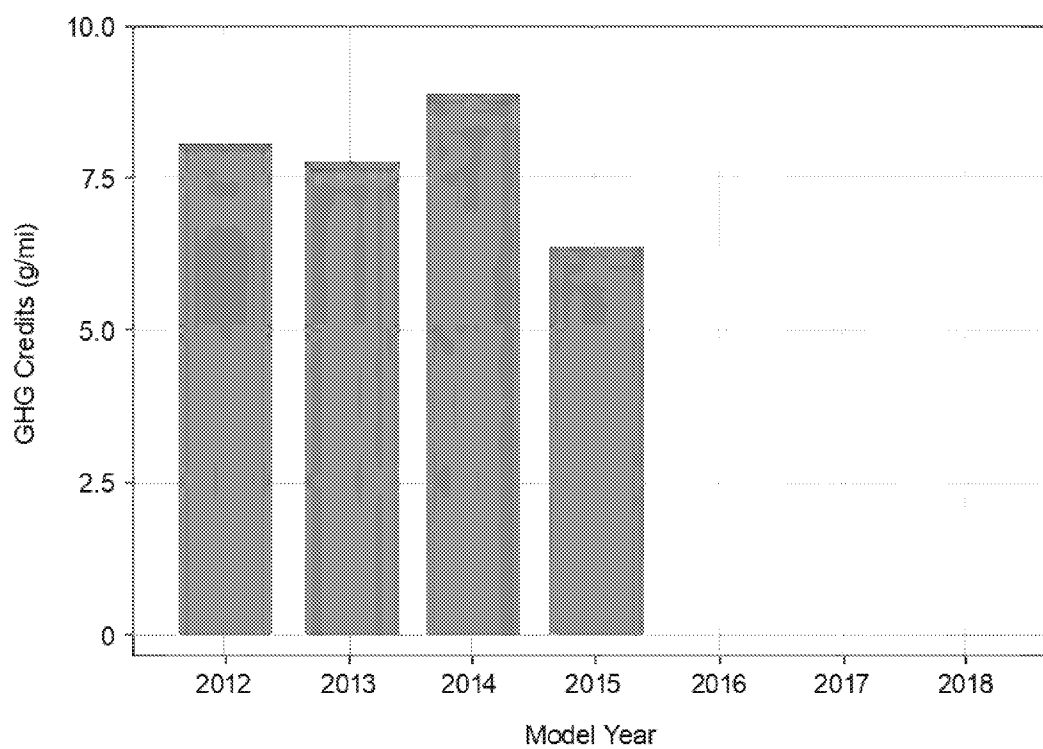
Credits for Improved Air Conditioning Systems

Almost all new cars and light trucks in the United States are equipped with air conditioning (A/C) systems. There are two mechanisms by which A/C systems contribute to the emissions of greenhouse gases: through leakage of hydrofluorocarbon (HFC) refrigerants (i.e., "direct" emissions) and through the combustion of fuel to provide mechanical power to the A/C system (i.e., "indirect" emissions). The EPA 2-cycle compliance tests do not measure either A/C refrigerant leakage or the increase in tailpipe emissions attributable to the additional engine load of A/C systems. Thus, the GHG emission regulations include a provision that allows manufacturers to earn optional credits for implementing technologies that reduce either type of A/C-related emissions.

Air Conditioning Leakage Credits

The high global warming potential (GWP)[17] of the current predominant automotive refrigerant, HFC-134a, means that leakage of a small amount of refrigerant will have a far greater impact on global warming than emissions of a similar volume of CO_2. The impacts of refrigerant leakage can be reduced significantly by using systems with leak-tight components, by using a refrigerant with a lower GWP, or by implementing both approaches.

A manufacturer choosing to generate A/C leakage credits is required to calculate a leakage "score" for the specific A/C system. This score is based on the number, performance, and technology of the components, fittings, seals, and hoses of the A/C system and is calculated as refrigerant emissions in grams per year, using the procedures specified by the SAE Surface Vehicle Standard J2727. The score is converted to a g/mi credit value based on the GWP of the refrigerant, then the g/mi value is used to determine the total tons of credits based on the production volume of the vehicles employing that A/C system.

In the 2012 model year, all leakage credits were based on improvements to the A/C system components (e.g., O-rings, seals, valves, and fittings). In the 2013 model year, GM and Honda introduced vehicles using HFO-1234yf, which has an extremely low global warming potential (GWP) of 4, as compared to a GWP of 1430 for HFC-134a. In the five model years since, low GWP refrigerant use has expanded to thirteen manufacturers and more than 60% of the fleet. BMW and Jaguar Land Rover have now fully implemented HFO-1234yf across their fleets, FCA and GM adoption levels exceed 90% of their 2018 model year fleets,

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[17] The global warming potential (GWP) represents how much a given mass of a chemical contributes to global warming over a given time period compared to the same mass of CO_2. The GWP of CO_2 is 1.0.

and both Honda and Volkswagen have topped 80%. Ford and Kia have exceeded 50% adoption of HFO-1234yf across their fleets. As a result, the overall fleet generated almost 18.5 Tg more CO_2 credits than it would have using solely HFC-134a; this is equivalent to a 5.4 g/mi reduction in CO_2 emissions for the entire 2018 model year fleet. The growth in usage of HFO-1234yf is illustrated in Figure 5.8.

Seventeen manufacturers reported A/C leakage credits in the 2018 model year. These manufacturers reported more than 38 Tg of A/C leakage credits in 2018, accounting for GHG reductions of 11.3 g/mi across the 2018 vehicle fleet.

Figure 5.8. HFO-1234yf Adoption by Manufacturer
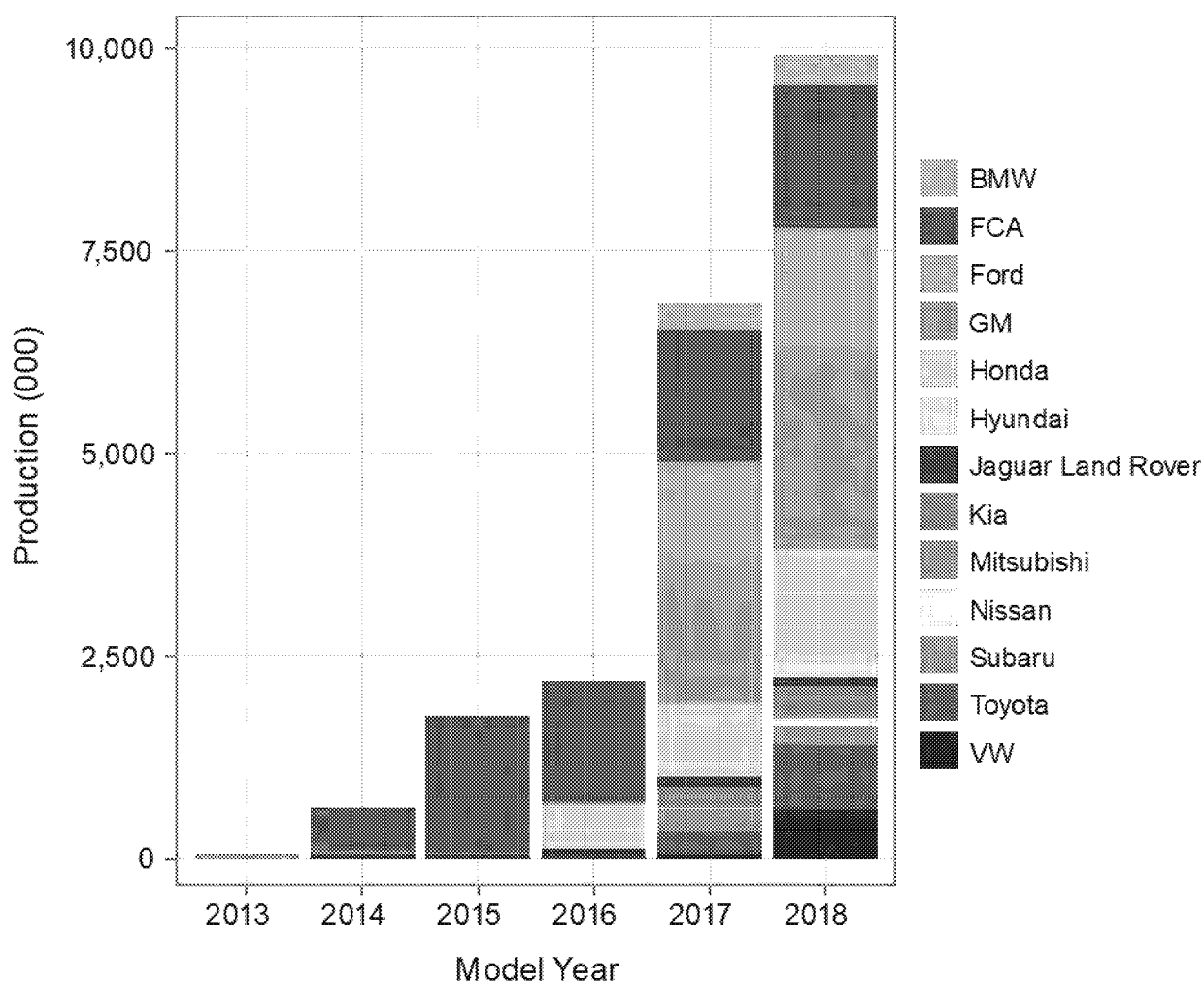
Air Conditioning Efficiency Credits

The A/C system also contributes to increased tailpipe CO_2 emissions through the additional work required by the engine to operate the compressor, fans, and blowers. This power demand is ultimately met by using additional fuel, which is converted into CO_2 by the engine during combustion and exhausted through the tailpipe. Increasing the overall efficiency of an A/C system reduces the additional load on the engine from A/C operation, and thereby leads to a reduction in fuel consumption and a commensurate reduction in GHG emissions.

Most of the additional load on the engine from A/C systems comes from the compressor, which pressurizes the refrigerant and pumps it around the system loop. A significant additional load may also come from electric or hydraulic fans, which move air across the condenser, and from the electric blower, which moves air across the evaporator and into the cabin. Manufacturers have several options for improving efficiency, including more efficient compressors, fans, and motors, and system controls that avoid over-chilling the air (and subsequently re-heating it to provide the desired air temperature). For vehicles equipped with automatic climate-control systems, real-time adjustment of several aspects of the overall system can result in improved efficiency.

The regulations provide manufacturers with a "menu" of A/C system technologies and associated credit values (in g/mi of CO_2), some of which are described above. These credits are capped at 5.7 g/mi for all vehicles in the 2012–2016 model years, and at 5.0 and 7.2 g/mi for cars and trucks, respectively, in the 2017 and later model years. The total tons of credits are then based on the total volume of vehicles in a model year using these technologies.

Sixteen manufacturers used the A/C credit provisions—leakage reductions, efficiency improvements, or both—as part of their compliance demonstration in the 2018 model year. These manufacturers reported a total of more than 17 Tg of A/C efficiency credits in the 2018 model year, accounting for about 5 g/mi across the 2018 fleet. Manufacturers were also allowed to generate A/C efficiency credits in the 2009–2011 model years (see the discussion of early credits in Section 5.C).

Air Conditioning Credit Summary

A summary of the A/C leakage and efficiency credits reported by the industry for all model years, including the early credit program years, is shown in Figure 5.9. Leakage credits have been more prevalent than efficiency credits, but both credit types are growing in use.

Figure 5.10 shows the benefit of A/C credits, translated from teragrams to grams per mile, for each manufacturer's fleet for the 2018 model year.

Jaguar Land Rover had the highest reported credit on a per vehicle g/mi basis, at 24 g/mi. Thus, A/C credits are the equivalent of about an 8% reduction from tailpipe emissions for Jaguar Land Rover. BMW, FCA, Ford, GM, and Volkswagen reported total A/C credits of around 20 g/mi, while most other manufacturers were in the range of 10-12 g/mi.

Figure 5.9. Fleetwide A/C Credits by Credit Type
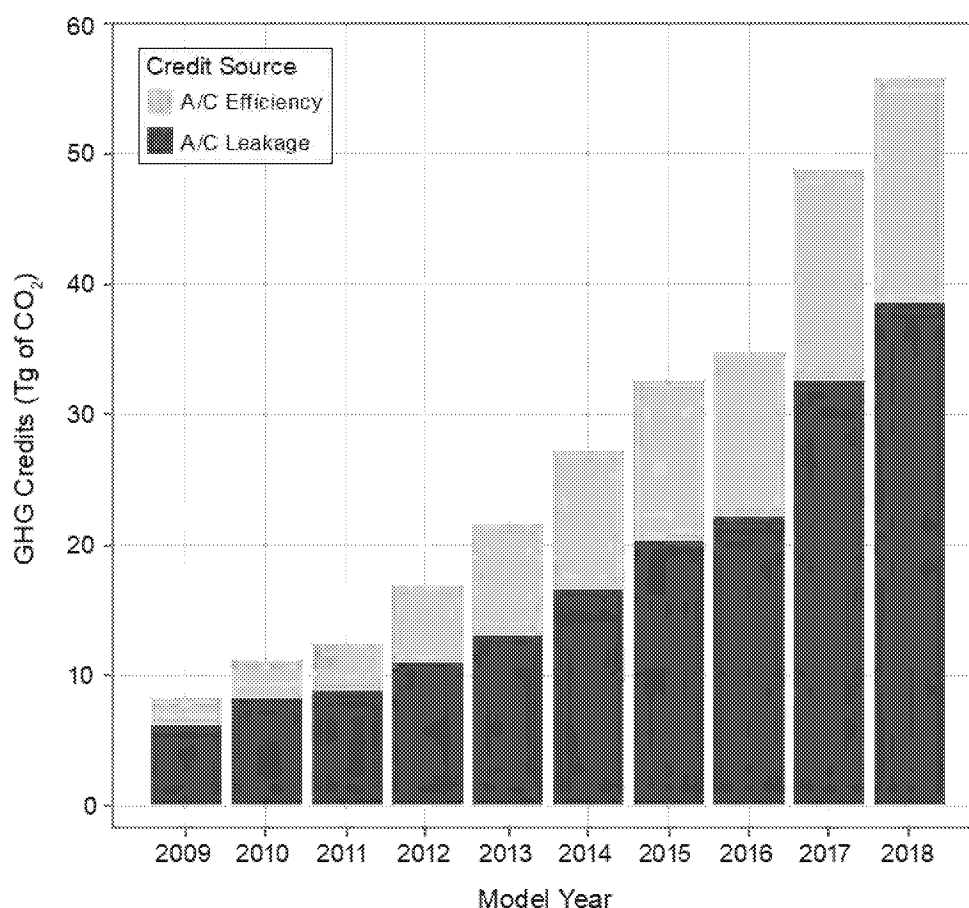
Figure 5.10. Total A/C Credits by Manufacturer for Model Year 2018
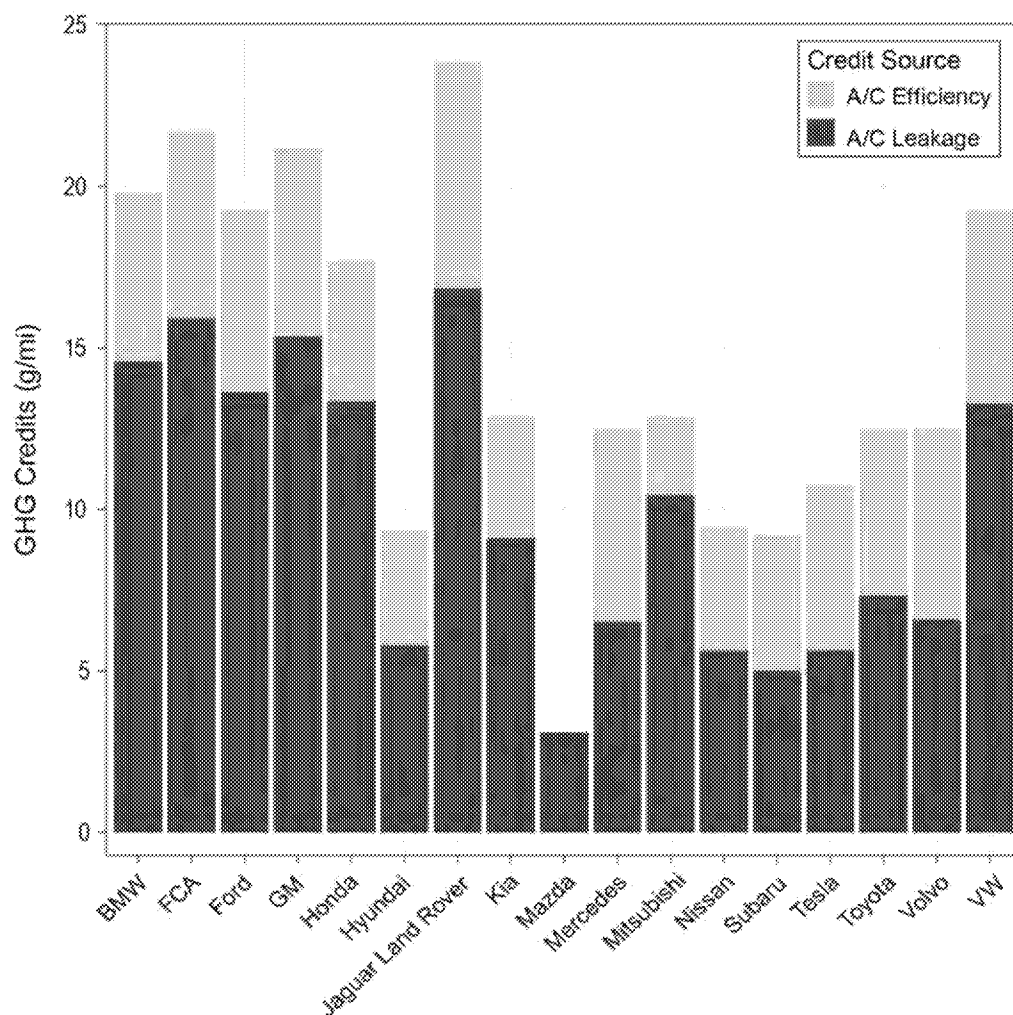
Credits for "Off-Cycle" Technology

In some cases, manufacturers employ technologies that result in CO_2 emission reductions that are not adequately captured on the 2-cycle test procedures. These benefits are acknowledged in EPA's regulations by giving manufacturers three pathways by which to accrue "off-cycle" CO_2 credits. The first, and most widely used, pathway is a predetermined list or "menu" of credit values for specific off-cycle technologies. The second pathway is to use a broader array of emissions testing (5-cycle testing) to demonstrate the CO_2 emission reduction. The third pathway allows manufacturers to seek EPA approval to use an alternative methodology to demonstrate CO_2 emission reductions.

Off Cycle Credits Based on the Menu

The first pathway to generating off-cycle credits is for a manufacturer to install technologies from a predetermined list or "menu" of technologies preapproved by EPA. The off-cycle credit menu provides specific credit values, or the calculation method for such values, for each technology.[18] Technologies from the menu may be used beginning in model year 2014. This pathway allows manufacturers to use conservative credit values established by EPA for a wide range of off-cycle technologies, with minimal data submittal or testing requirements.

The amount of credit awarded varies for each technology and between cars and trucks. The impact of credits from this pathway on a manufacturer's fleet is capped at 10 g/mi, meaning that any single vehicle might accumulate more than 10 g/mi, but the cumulative effect on a single manufacturer's fleet may not exceed a credit of more than 10 g/mi. The regulations clearly define each technology and any requirements that apply for the technology to generate credits. Figure 5.11 shows the adoption of menu technologies, by manufacturer. These credits were widely used in model year 2018, with 94% of off-cycle credits generated via the menu pathway. Each of these technologies is discussed below.

Active Aerodynamics

Active aerodynamics refers to technologies which are automatically activated to improve the aerodynamics of a vehicle under certain conditions. These include grill shutters and spoilers, which allow air to flow over and around the vehicle more efficiently, and suspension systems that improve air flow at higher speeds by reducing the height of the vehicle. Credits are variable and based on the measured improvement in the coefficient of drag, a test metric that reflects the efficiency of airflow around a vehicle.

Most manufacturers implemented at least some level of active aerodynamics on their model year 2018 vehicles. Tesla reported the highest implementation, at 100% of all new vehicles, and realized a CO_2 reduction of just over 1 g/mi. Ford achieved a similar reduction with almost 90% of their fleet equipped with active aerodynamic technologies. Overall, almost 40% of new vehicles qualified for these credits, reducing overall fleet CO_2 emissions by 0.4 g/mi.

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[18] See 40 CFR 86.1869-12(b).

Manufacturer	Active Aerodynamic Improvements	Active Seat Ventilation	Active Cabin Ventilation	Glass or Glazing	Solar Reflecting Coating	Passive Cabin Ventilation	Active Engine Warm-up	Active Transmission Warm-up	Engine Idle Start Stop	High Efficiency Lighting
BMW	25%	8%	100%				23%		32%	100%
FCA	23%	32%		98%	22%	97%	70%	37%	46%	55%
Ford	89%	22%		100%	7%	48%	26%	60%	62%	56%
GM	68%	19%		100%	23%	100%	47%		43%	93%
Honda	39%	7%		98%			8%	92%	7%	100%
Hyundai	2%	11%		87%	19%		2%	77%	2%	60%
Jaguar Land Rover	78%	45%		100%		78%		46%	100%	100%
Kia	5%	10%		100%	21%		5%	63%	9%	55%
Mazda	61%	3%		94%				95%		67%
Mercedes		17%		88%						97%
Mitsubishi				78%					4%	87%
Nissan	48%	5%		67%	14%		29%	63%	1%	75%
Subaru	32%			91%				87%		52%
Tesla	100%		100%	100%						100%
Toyota	5%	27%		99%	25%	84%	30%	39%	16%	63%
Volkswagen	26%	22%		59%	6%		85%	7%	70%	99%
Volvo		9%				100%	100%		100%	100%
All Manufacturers	40%	18%	3%	90%	14%	48%	32%	44%	29%	74%

Credit Type
- Active Aerodynamic Improvements
- Thermal Control Technologies
- Active Warmup
- Engine Idle Start Stop
- High Efficiency Lighting

Thermal Control Technologies

Thermal control systems help to maintain a comfortable air temperature of the vehicle interior, without the use of the A/C system. These technologies lower the load on the A/C system and thus the amount of fuel required to run the A/C system, subsequently lowering GHG tailpipe emissions. The thermal control technologies included in the off-cycle menu are:

- Active and passive cabin ventilation – Active systems use mechanical means to vent the interior, while passive systems rely on ventilation through convective air flow. Credits available for this technology range from 1.7 to 2.8 g/mi.

- Active seat ventilation – These systems move air through the seating surface, transferring heat away from the vehicle occupants. Credits are 1.0 g/mi for cars and 1.3 g/mi for trucks.

- Glass or glazing – Credits are available for glass or glazing technologies that reduce the total solar transmittance through the glass, thus reducing the heat from the sun that reaches the occupants. The credits are calculated based on the measured solar transmittance through the glass and on the total area of glass on the vehicle.

- Solar reflective surface coating – Credits are available for solar reflective surface coating (e.g., paint) that reflects at least 65% of the infrared solar energy. Credits are 0.4 g/mi for cars and 0.5 g/mi for trucks.

Active seat ventilation was used by many manufacturers and the rate of implementation jumped from about five percent in model year 2016 to 18% in model year 2018. Jaguar Land Rover remained the leader in adopting active seat ventilation, with implementation on almost half of their vehicles (this is consistent with this technology being largely limited to luxury brands or models).

As was the case in the previous model year, there was significant penetration of glass or glazing technology across manufacturers, with a majority reporting this technology on more than 75% of their vehicles, and ten manufacturers approaching a 100% implementation rate. Ninety percent of the 2018 model year fleet was equipped with glass or glazing technologies, contributing to the fleetwide GHG reduction of 2.4 g/mi from this technology group. Five manufacturers – FCA, GM, Jaguar Land Rover, Tesla, and Toyota – achieved reductions of more than 3 g/mi from this technology group, largely from their use of glass and cabin ventilation technologies.

Due to the likelihood of synergistic effects among the various thermal technologies, the total per-vehicle credit allowed from this technology group is capped at 3.0 g/mi for cars and 4.3 g/mi for trucks. Because this category of credits is capped, the actual credits attributable to each technology in this category cannot be accurately summarized. For example, credits for a car with active cabin ventilation (2.1 g/mi), active seat ventilation (1.0 g/mi), and reflective paint (0.4 g/mi) would total to 3.5 g/mi, thus exceeding the cap by 0.5 g/mi. Credits for this car would have to be truncated at 3.0 g/mi, and there is no non-arbitrary methodology to assign that 3.0 g/mi to the array of technologies involved. Therefore, this report can only detail the credits derived from the overall category, but not from the individual technologies in the category.

Active Engine and Transmission Warmup

Active engine and transmission warmup systems use heat from the vehicle that would typically be wasted (exhaust heat, for example) to warm up key elements of the engine, allowing a faster transition to more efficient operation. An engine or transmission at its optimal operating temperature minimizes internal friction, and thus operates more efficiently and reduces tailpipe CO_2 emissions. Systems that use a single heat-exchanging loop that serves both transmission and engine warmup functions are eligible for either engine or transmission warmup credits, but not both. Active engine and transmission warmup technologies are each worth credit up to 1.5 g/mi for cars and 3.2 g/mi for trucks.

Most manufacturers adopted warmup technologies for their engines, transmissions, or both. FCA employed active engine warmup in more than 70% of its new vehicles and active transmission warmup in more than one-third, resulting in an aggregate CO_2 reduction for their fleet of about 3.3 g/mi. Mazda led manufacturers in installing active transmission warmup technology, which appeared in 95% of its new vehicles, contributing to a benefit from warmup technologies for Mazda of about 2.2 g/mi. Active engine warmup was installed in about one-third of all new vehicles, and active transmission warmup in 44% of the fleet, resulting in a CO_2 reduction of about 1.8 g/mi across the 2018 model year fleet.

Engine Idle Stop/Start

Engine idle stop/start systems allow the engine to turn off when the vehicle is at a stop, automatically restarting the engine when the driver releases the brake and/or applies pressure to the accelerator. If equipped with a switch to disable the system, EPA must determine that the predominant operating mode of the system is the "on" setting (defaulting to "on" every time the key is turned on is one basis for such a determination). Thus, some vehicles with these systems are not eligible for credits. Credits range from 1.5

to 4.4 g/mi and depend on whether the system is equipped with an additional technology that, at low ambient temperatures, allows heat to continue to be circulated to the vehicle occupants when the engine is off during a stop-start event.

The implementation of stop/start has been increasing rapidly, as discussed in Section 4, which aggregates and reports on these systems regardless of the regulatory eligibility for credits. Almost 30% of new vehicles qualified for and claimed this credit, resulting in a fleetwide CO_2 reduction of about 1.1 g/mi. Jaguar Land Rover and Volvo claimed start/stop credits on 100% of their vehicles in model year 2018, providing each of these manufacturers with CO_2 reductions of 4 g/mi. Other manufacturers have not come close to this adoption rate, with Volkswagen being the closest at 70%.

High Efficiency Exterior Lights

High efficiency lights (e.g., LEDs) reduce the total electric demand, and thus the fuel consumption and related GHG emissions, of a lighting system in comparison to conventional incandescent lighting. Credits are based on the specific lighting locations, ranging from 0.06 g/mi for turn signals and parking lights to 0.38 g/mi for low beams. The total of all lighting credits summed from all lighting locations may not exceed 1.0 g/mi.

Unlike some other off-cycle technologies, safety regulations require that all vehicles must be equipped with lights, and the popularity of high efficiency lights across manufacturers may reflect that lighting improvements are relatively straightforward to implement. All manufacturers reporting off-cycle credits indicated implementation on at least half of their fleet, with half of the manufacturers at or approaching 100% implementation. About three quarters of new vehicles used high efficiency lighting in some form in model year 2018, reducing fleetwide CO_2 emissions by 0.3 g/mi.

Solar Panels

Vehicles that use batteries for propulsion, such as electric, plug-in hybrid electric, and hybrid vehicles may receive credits for solar panels that are used to charge the battery directly or to provide power directly to essential vehicle systems (e.g., heating and cooling systems). Credits are based on the rated power of the solar panels. Nissan claimed this credit in model year 2017 for a very small number of vehicles, but no manufacturer claimed use of solar panels in model year 2018.

As shown in Table 5.3, manufacturers are using a mix of off-cycle menu technologies, though each uses and benefits from the individual technologies to differing degrees. In

model year 2018, the industry achieved 6 g/mi of credits from the menu, based on a production weighted average of credits across all manufacturers.

Table 5.3. Model Year 2018 Off-Cycle Technology Credits from the Menu, by Manufacturer and Technology (g/mi)

Manufacturer	Active Aero- dynamics	Active Engine Warmup	Active Trans Warmup	Thermal Controls	Engine Start- Stop	High Efficiency Lighting	Total Menu Credits
BMW	0.5	0.6	-	2.4	1.0	0.8	5.4
FCA	0.2	2.1	1.2	3.8	2.0	0.1	9.4
Ford	1.2	0.7	1.7	2.9	2.5	0.2	9.2
GM	0.8	1.1	-	3.6	1.4	0.5	7.3
Honda	0.2	0.2	2.0	1.0	0.3	0.3	3.9
Hyundai	0.0	0.0	1.2	0.8	0.0	0.2	2.2
Jaguar Land Rover	0.5	-	1.4	3.6	4.2	0.8	10.0
Kia	0.0	0.1	1.3	1.0	0.1	0.1	2.5
Mazda	0.2	-	2.1	0.5	-	0.1	2.9
Mercedes	-	-	-	1.1	-	0.7	1.8
Mitsubishi	-	-	-	0.8	0.1	0.3	1.2
Nissan	0.2	0.6	1.3	0.9	0.0	0.2	3.2
Subaru	0.2	-	2.5	1.0	-	0.2	3.9
Tesla	1.1	-	-	3.1	-	0.7	4.9
Toyota	0.0	0.9	0.2	3.2	0.7	0.3	5.3
Volkswagen	0.2	2.2	0.2	0.8	2.3	0.7	6.3
Volvo	-	2.8	-	2.3	4.0	1.0	10.0
All Manufacturers	**0.4**	**0.8**	**1.0**	**2.4**	**1.1**	**0.3**	**6.0**

*Data updated on 3/11/20

Off-Cycle Credits Based on 5-Cycle Testing

In cases where additional laboratory testing can demonstrate emission benefits, a second pathway allows manufacturers to use a broader array of emission tests (known as "5-cycle" testing because the methodology uses five different testing procedures) to demonstrate and justify off-cycle CO_2 credits.[19] The additional emission tests allow emission benefits to be demonstrated over some elements of real-world driving not captured by the GHG compliance tests, including high speeds, rapid accelerations, and cold temperatures. Credits determined according to this methodology do not undergo additional public review.

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[19] See 40 CFR 86.1869-12(c).

GM is the only manufacturer to date to have claimed off-cycle credits based on 5-cycle testing. These credits are for an auxiliary electric pump used on certain GM gasoline-electric hybrid vehicles to keep engine coolant circulating in cold weather while the vehicle is stopped and the engine is off. This enables the engine stop-start system to turn off the engine more often during cold weather, while maintaining a comfortable temperature inside the vehicle. GM received off-cycle credits during the early credits program for equipping hybrid full size pick-up trucks with this technology and has since applied the technology to several other vehicles through model year 2017. They did not claim credits for this technology in model year 2018.

Off-Cycle Credits Based on an Alternative Methodology

This third pathway for off-cycle technology credits allows manufacturers to seek EPA approval to use an alternative methodology for determining the off-cycle technology CO_2 credits.[20] This option is only available if the benefit of the technology cannot be adequately demonstrated using the 5-cycle methodology. Manufacturers may also use this option for model years prior to 2014 to demonstrate CO_2 reductions for technologies that are on the off-cycle menu, or reductions that exceed those available via use of the menu. The regulations require that EPA seek public comment on and publish each manufacturer's application for credits sought using this pathway. About half of the manufacturers have petitioned for and been granted credits using this pathway, four of which reported credits in the 2018 model year for two technologies.[21]

In the fall of 2013, Mercedes requested off-cycle credits for the following off-cycle technologies in use or planned for implementation in the 2012-2016 model years: stop-start systems, high-efficiency lighting, infrared glass glazing, and active seat ventilation. EPA approved methodologies for Mercedes to determine these off-cycle credits in September 2014.

Subsequently, FCA, Ford, and GM requested off-cycle credits under this pathway, which EPA approved in September 2015. FCA and Ford submitted applications for off-cycle credits from high efficiency exterior lighting, solar reflective glass/glazing, solar reflective paint, and active seat ventilation. Ford's application also demonstrated off-cycle benefits from active aerodynamic improvements (grill shutters), active transmission warm-up, active

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[20] See 40 CFR 86.1869-12(d).

[21] EPA maintains a web page on which we publish the manufacturers' applications for these credits, the relevant Federal Register notices, and the EPA decision documents. See https://www.epa.gov/vehicle-and-engine-certification/compliance-information-light-duty-greenhouse-gas-ghg-standards.

engine warm-up technologies, and engine idle stop-start. GM's application described the real-world benefits of an A/C compressor made by Denso with variable crankcase suction valve technology. EPA approved the credits for FCA, Ford, and GM in September of 2015. EPA approved additional credits under this pathway for the Denso compressor in 2017 for BMW, Ford, GM, Hyundai, Toyota, and Volkswagen.

In December 2016, EPA approved a methodology for determining credits from high-efficiency alternators that Ford had applied for in 2016. EPA subsequently approved high-efficiency alternator credits also for FCA, GM, and Toyota. High efficiency alternators use new technologies that reduce the overall load on the engine while continuing to meet the electrical demands of the vehicle systems, resulting in lower fuel consumption and lower CO_2 emissions.

In September of 2017 GM applied for credits under this pathway for "active climate-controlled seats," which provide cooled air directly to the occupants through the seats, thus reducing the overall load on the air conditioning system. GM reported credits for this technology in the 2018 model year.

Most of the approved credits have been for previous model years, and thus are not included in the detailed reporting for the 2018 model year in this section. Credit balances have been updated to include retroactive credits that have been reported to EPA, and any relevant tables that include data from previous model years will reflect the addition of these credits. Table 5.4 shows the impact of the credits submitted for the air conditioning systems, high-efficiency alternators, and active climate-controlled seats. On a total fleetwide basis, the aggregated credit is less than 0.5 g/mi.

Table 5.4. Model Year 2018 Off-Cycle Technology Credits from an Alternative Methodology, by Manufacturer and Technology (g/mi)

Manufacturer	Combined Condenser A/C System	Denso SAS A/C Compressor	High-Efficiency Alternator	Active Climate Control Seats	Total Alternative Methodology Credits
FCA	-	-	0.5	-	0.5
Ford	-	-	0.6	-	0.6
GM		0.7	0.6	0.0	1.3
Hyundai	0.0	-	-	-	0.0
Toyota	-	0.2	0.3	-	0.6
All Manufacturers	**0.0**	**0.1**	**0.3**	**0.0**	**0.4**

Off-Cycle Credit Summary

In total, the industry achieved 6.5 g/mi of off-cycle credits in model year 2018. More than 90% of those credits were claimed using technologies, and credit definitions, on the off-cycle menu. The remaining credits were due almost entirely to manufacturer submitted alternative methodologies. Figure 5.12 shows the average number of credits, in g/mi, that each manufacturer achieved in model year 2018. Ford led the way with the highest gram per mile benefit from off-cycle credits, followed closely by FCA, Jaguar Land Rover, GM, and Volvo. Most manufacturers achieved at least some off-cycle credits; BYD was the only manufacturer to not report any off-cycle credits for model year 2018.

Figure 5.12. Total Off-Cycle Credits by Manufacturer for Model Year 2018
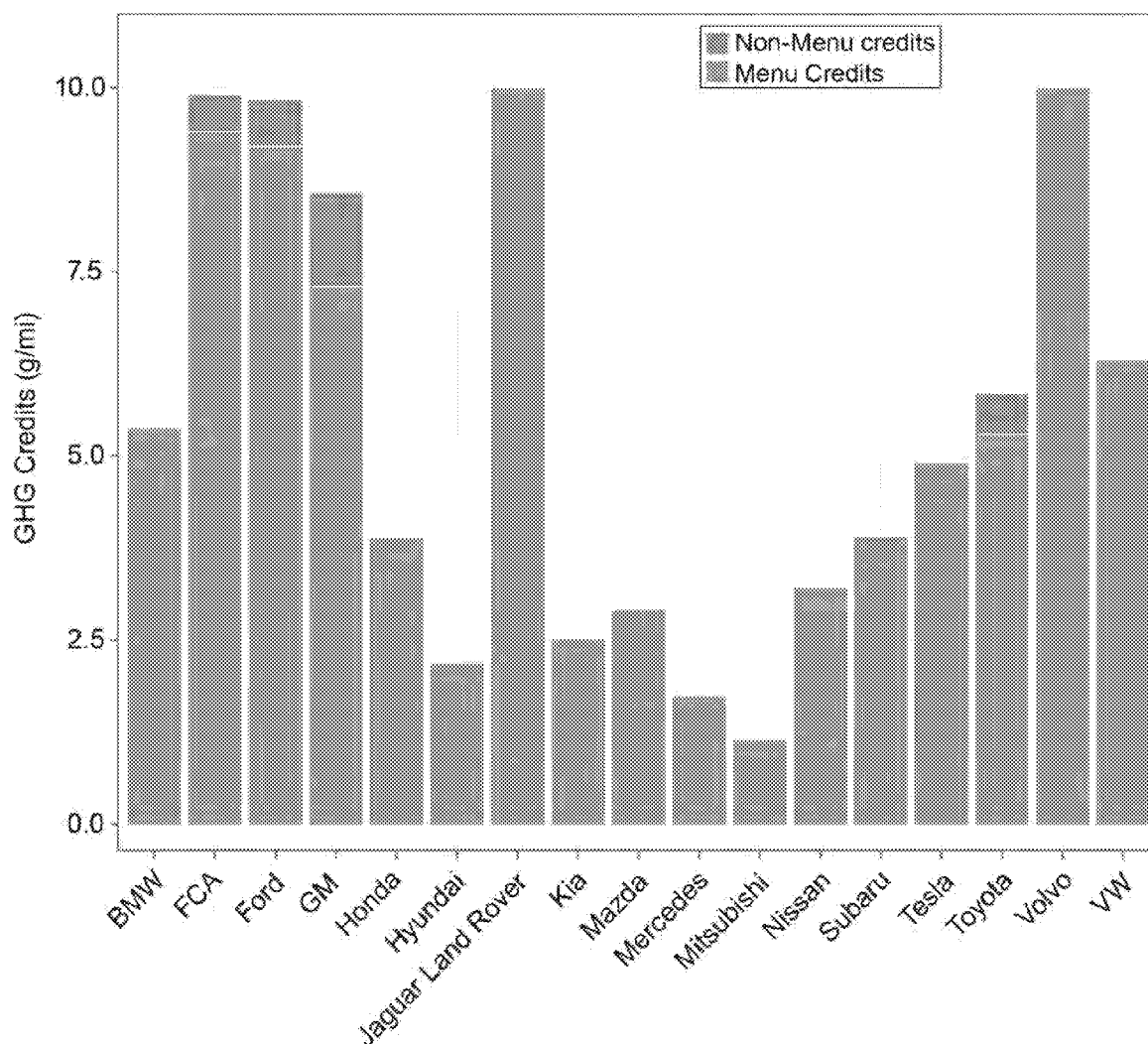
* Data updated on 3/11/20

Alternative Standards for Methane and Nitrous Oxide

As part of the EPA GHG Program, EPA set emission standards for methane (CH_4) and nitrous oxide (N_2O) at 0.030 g/mi for CH_4 and 0.010 g/mi for N_2O. Current levels of CH_4 and N_2O emissions are generally well below these established standards, however the caps were set to prevent future increases in emissions.

There are three different ways for a manufacturer to demonstrate compliance with these standards. First, manufacturers may submit test data as they do for all other non-GHG emission standards; this option is used by most manufacturers. Because there are no credits or deficits involved with this approach, and there are no consequences with respect to the CO_2 fleet average calculation, the manufacturers are not required to submit this data as part of their GHG reporting. Hence, this GHG compliance report does not include information from manufacturers using this option.

The second option for manufacturers is to include CH_4 and N_2O, on a CO_2-equivalent basis, when calculating their fleet average performance values, in lieu of demonstrating compliance with the regulatory caps. This method directly accounts for CH_4 and N_2O, increasing the performance value of a manufacturer's fleets, while the standards remain unchanged. Analyses of emissions data have shown that use of this option may add approximately 3 g/mi to a manufacturer's fleet average. Only Subaru chose to use this approach in the 2018 model year.

The third option for complying with the CH_4 and N_2O standards allows manufacturers to propose an alternative, less stringent CH_4 and/or N_2O standard for any vehicle that may have difficulty meeting the specific standards. However, manufacturers that use this approach must also calculate a deficit (in Megagrams) based on the less stringent standards and on the production volumes of the vehicles to which those standards apply. Seven manufacturers made use of the flexibility offered by this approach in the 2018 model year. In aggregate, the industry created a deficit of about 0.4 Tg due to this approach.

Alternative Standards for Small Volume Manufacturers

EPA established the Temporary Lead-time Allowance Alternative Standards (TLAAS) to assist manufacturers with limited product lines that may be especially challenged in the early years of EPA's GHG program. The TLAAS program was established to provide additional lead-time for manufacturers with narrow product offerings which may not be able to take full advantage of averaging or other program flexibilities due to the limited

scope of the types of vehicles they sell. This program was only available during the 2012–2015 model years and is only shown in historic data.

Summary of Manufacturer Performance

Each of the flexibilities described here have been used by manufacturers as part of their compliance strategies under the GHG program. As described above, the availability of these flexibilities, and the magnitude of their impact, has varied both by manufacturer and model year. Table 5.5 through Table 5.10 below detail the impact of these flexibilities by manufacturer for model year 2017, and for the aggregated industry over the course of the GHG Program. The Performance Values in these tables can be derived by subtracting the credits from and adding the deficits to the 2-Cycle Tailpipe value. The TLAAS credits are excluded from this calculation because they are part of the standard and not tied to the emissions performance.

Table 5.5. Manufacturer Performance in Model Year 2018, All (g/mi)

Manufacturer	2-Cycle Tailpipe	Credits					CH₄ & N₂O Deficit	Performance Value
		FFV	TLAAS	A/C	ATVs	Off-Cycle		
BMW	268	-	-	19.8	6.9	5.4	0.2	236
BYD Motors	0	-	-	-	215.1	-	-	-215
FCA	327	-	-	21.7	1.5	9.9	0.1	294
Ford	315	-	-	19.3	0.5	9.8	0.5	286
GM	309	-	-	21.2	1.8	8.6	0.1	278
Honda	229	-	-	17.7	1.8	3.9	-	206
Hyundai	245	-	-	9.4	0.2	2.3	-	233
Jaguar Land Rover	317	-	-	23.8	-	10.0	-	283
Kia	253	-	-	12.9	0.8	2.5	-	237
Mazda	239	-	-	3.1	-	2.9	-	233
Mercedes	299	-	-	12.5	1.6	1.8	-	284
Mitsubishi	229	-	-	12.9	1.4	1.2	-	213
Nissan	257	-	-	9.5	2.4	3.2	0.0	241
Subaru	240	-	-	9.2	-	3.9	-	227
Tesla	0	-	-	10.7	227.9	4.9	-	-244
Toyota	273	-	-	12.5	0.9	5.8	0.1	254
Volkswagen	282	-	-	19.3	0.8	6.3	0.0	256
Volvo	272	-	-	12.5	4.5	10.0	-	245
All Manufacturers	**280**	**-**	**-**	**16.3**	**3.9**	**6.5**	**0.1**	**253**

Table 5.6. Industry Performance by Model Year, All (g/mi)

Model Year	2-Cycle Tailpipe	Credits					CH₄ & N₂O Deficit	Performance Value
		FFV	TLAAS	A/C	ATVs	Off-Cycle		
2012	302	8.1	0.6	6.1		1.0	0.2	287
2013	294	7.8	0.5	6.9		1.1	0.3	278
2014	294	8.9	0.2	8.5		3.3	0.2	273
2015	286	6.4	0.3	9.4		3.4	0.2	267
2016	285	-	-	10.3		3.6	0.1	271
2017	284	-	-	13.7	2.3	5.1	0.2	263
2018	280	-	-	16.3	3.9	6.5	0.1	253

Table 5.7. Manufacturer Performance in Model Year 2018, Car (g/mi)

| Manufacturer | 2-Cycle Tailpipe | Credits | | | | | CH₄ & N₂O Deficit | Performance Value |
		FFV	TLAAS	A/C	ATVs	Off-Cycle		
BMW	253	-	-	18.4	7.8	4.2	0.1	223
BYD Motors	0	-	-	-	215.1	-	-	-215
FCA	302	-	-	18.1	1.3	4.2	0.0	278
Ford	253	-	-	16.0	1.7	4.7	0.2	231
GM	234	-	-	16.7	5.4	6.8	0.1	205
Honda	203	-	-	15.3	3.0	2.5	-	182
Hyundai	241	-	-	9.4	0.2	2.1	-	229
Jaguar Land Rover	269	-	-	18.8	-	6.5	-	244
Kia	233	-	-	13.0	1.1	2.1	-	217
Mazda	225	-	-	2.5	-	1.9	-	221
Mercedes	269	-	-	11.0	1.7	1.2	-	255
Mitsubishi	197	-	-	6.4	3.4	0.8	-	186
Nissan	225	-	-	8.9	3.7	2.3	0.1	210
Subaru	244	-	-	6.3	-	1.7	-	236
Tesla	0	-	-	10.7	225.2	4.8	-	-241
Toyota	216	-	-	11.4	1.9	4.4	0.1	198
Volkswagen	257	-	-	15.3	1.4	3.6	0.0	237
Volvo	247	-	-	9.3	4.4	6.7	-	227
All Manufacturers	**228**	**-**	**-**	**13.0**	**7.9**	**3.7**	**0.0**	**204**

Table 5.8. Industry Performance by Model Year, Car (g/mi)

| Model Year | 2-Cycle Tailpipe | Credits | | | | | CH₄ & N₂O Deficit | Performance Value |
		FFV	TLAAS	A/C	ATVs	Off-Cycle		
2012	259	4.0	0.2	5.4	-	0.6	0.1	249
2013	251	4.0	0.1	6.3	-	0.7	0.3	240
2014	250	4.6	0.1	7.5	-	2.2	0.3	236
2015	243	3.1	0.0	8.1	-	2.3	0.1	230
2016	240	-	-	8.8	-	2.3	0.1	229
2017	235	-	-	10.1	4.5	3.0	0.0	217
2018	228	-	-	13.0	7.9	3.7	0.0	204

Table 5.9. Manufacturer Performance in Model Year 2018, Truck (g/mi)

| Manufacturer | 2-Cycle Tailpipe | Credits | | | | | CH₄ & N₂O Deficit | Performance Value |
		FFV	TLAAS	A/C	ATVs	Off-Cycle		
BMW	304	-	-	23.0	4.9	8.1	0.5	268
FCA	332	-	-	22.5	1.5	11.1	0.1	297
Ford	343	-	-	20.8	-	12.1	0.6	311
GM	348	-	-	23.5	-	9.5	0.1	315
Honda	269	-	-	21.3	-	6.1	-	242
Hyundai	340	-	-	6.9	-	5.4	-	328
Jaguar Land Rover	322	-	-	24.4	-	10.4	-	287
Kia	320	-	-	12.3	-	4.1	-	304
Mazda	261	-	-	4.1	-	4.5	-	252
Mercedes	335	-	-	14.3	1.5	2.4	-	317
Mitsubishi	252	-	-	17.7	-	1.4	-	233
Nissan	313	-	-	10.5	-	5.0	-	298
Subaru	239	-	-	10.0	-	4.5	-	225
Tesla	0	-	-	12.4	292.4	8.3	-	-313
Toyota	324	-	-	13.5	-	7.0	0.1	304
Volkswagen	300	-	-	22.1	0.4	8.2	-	269
Volvo	279	-	-	13.5	4.6	11.0	-	250
All Manufacturers	**320**	**-**	**-**	**19.0**	**0.6**	**8.7**	**0.2**	**292**

Table 5.10. Industry Performance by Model Year, Truck (g/mi)

| Model Year | 2-Cycle Tailpipe | Credits | | | | | CH₄ & N₂O Deficit | Performance Value |
		FFV	TLAAS	A/C	ATVs	Off-Cycle		
2012	369	14.5	1.3	7.3		1.6	0.3	346
2013	360	13.8	1.1	7.9		1.7	0.3	337
2014	349	14.3	0.3	9.7		4.6	0.1	321
2015	336	10.3	0.6	11.0		4.6	0.2	310
2016	332	-	-	11.8		5.1	0.2	315
2017	330	-	-	17.2	0.2	7.1	0.3	306
2018	320	-	-	19.0	0.6	8.7	0.2	292

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C. End of Year Credit Balance

Each model year, manufacturers must determine their tailpipe CO_2 emissions, the flexibilities that they are eligible to use, and the performance values for their car and truck fleets. The car and truck performance values can be compared to the respective footprint-based CO_2 standards to determine "net compliance" in a model year for each fleet. This value provides a snapshot of how each manufacturer's fleet performed within the model year, but it is not an enforceable compliance value and does not give a complete picture of the manufacturer's status under the GHG program, due to the ABT-based design of the overall GHG program.

As discussed at the beginning of this section, the GHG program allows manufacturers to take advantage of averaging, banking, and trading options. The averaging provisions allow manufacturers to use a production-weighted standard for car and truck fleets, as opposed to standards for individual vehicles. It also allows manufacturers to use surplus credits from their car fleet to offset a shortfall within their truck fleet, or vice versa, within a model year. The banking provisions allow manufacturers to carry credits, or deficits, between model years, and the trading provisions allow manufacturers to trade credits between manufacturers.

The following discussion provides more detail on the credit program and how credit balances are determined. This includes accounting for credit expirations and forfeitures, credits earned under the early credit program, each manufacturer's annual standards and performance values, and credit transactions between companies. The discussion will focus on credits in terms of Megagrams (or Teragrams), which is how the credits are accounted for within the GHG program.

Expiration or Forfeiture of Credits

All credits earned within the GHG program have expiration dates. However, the only credits that have expired so far were credits earned under the early credit program (discussed below) from model year 2009. All credits earned from model years 2010 to 2016, which make up the majority of credits currently held by manufacturers, will expire at the end of model year 2021. Beginning in model year 2017, all credits have a 5-year lifetime; for example, credits earned in model year 2018 will expire at the end of model year 2023.

A limited number of credits have been forfeited by several manufacturers. Although forfeiture and expiration both have fundamentally the same effect – a loss or removal of credits – forfeiture is considered a different and less common mechanism, brought about

by unique circumstances. Hyundai and Kia forfeited a specified quantity of 2013 model year credits after an investigation into their testing methods that concluded with a settlement announced on November 3, 2014.

Volkswagen similarly forfeited some credits, deducted from their 2017 model year balance. In the course of the investigation concerning defeat devices in Volkswagen's diesel vehicles, the EPA discovered that the company employed software to manage vehicle transmissions in gasoline vehicles. This software causes the transmission to shift gears during the EPA-prescribed emissions test in a manner that sometimes optimizes fuel economy and greenhouse gas (GHG) emissions during the test, but not under normal driving conditions. This resulted in inflated fuel economy values for some vehicles. Volkswagen forfeited credits to account for the higher CO_2 emissions of these vehicles in actual use.

Additional manufacturers forfeited credits because of their participation in the Temporary Lead Time Alternative Allowance Standards (TLAAS). Opting into these less stringent standards, which are no longer available, came with some restrictions, including the requirement that any credits accumulated by using the TLAAS standards may not be used by or transferred to a fleet meeting the primary standard. This impacted Porsche, which was bought by VW in 2012. Porsche held some credits earned against the TLAAS standards at the time they were merged with VW, and VW was not participating in the TLAAS program. Thus, those credits could not carry over to the merged company and were lost. Similarly, Mercedes and Volvo reached the end of the TLAAS program, which applied through the 2015 model year, with credits in their TLAAS bank that could not be transferred to their post-2015 bank and thus were forfeited.

Credits for Early Adoption of Technology

The GHG program included an optional provision that allowed manufacturers to generate credits in the 2009–2011 model years, prior to the implementation of regulatory standards in model year 2012. This flexibility allowed manufacturers to generate credits for achieving tailpipe CO_2 emissions targets or introducing technology before model year 2012. The pathways for earning credits under the early credit program were like the flexibilities built into the annual GHG requirements, including improved A/C systems, off-cycle credits, and electric, plug-in hybrid, and fuel cell vehicles.

To earn credits based on tailpipe CO_2 performance, manufacturers could demonstrate tailpipe emissions levels below either California or national standards, dependent on the state the car was sold in. California developed GHG standards prior to the adoption of the EPA GHG program, and some states had adopted these standards. In all other states, CO_2

levels were calculated based on the national CAFE standards. The early credits program required that participating manufacturers determine credits for each of the three model years. Thus, even manufacturers with a deficit in one or more of the early model years (i.e., their tailpipe CO_2 performance was worse than the applicable emissions threshold) could benefit from the early credits program if their net credits over the three years was a positive value.

Due to concerns expressed by stakeholders during the rulemaking process, 2009 model year credits could not be traded between companies and were limited to a 5-year credit life. Thus, all credits earned in model year 2009 expired at the end of the 2014 model year if not already used. The remaining 2010–2011 model year credits were banked and may be used until the 2021 model year.

Sixteen manufacturers participated in the early credits program, generating about 234 Tg of credits in total. Figure 5.13 shows the early credits earned, expired, and remaining for each manufacturer. Of the 234 Tg of early credits earned by manufacturers, 76 Tg, or about one-third of the early credits accumulated by manufacturers in the 2009–2011 model years, were 2009 credits that expired. The remaining 2010–2011 model year credits will be available until the 2021 model year. Note that Figure 5.13 shows how many 2010-2011 credits were reported; it does not show how many have since been used, nor how many remain, after the 2018 model year. The impact of credit trading is not accounted for in Figure 5.13, thus the figure does not show how many of these early credits remain for each manufacturer at the end of the 2018 model year.

Figure 5.13. Early Credits Reported and Expired by Manufacturer
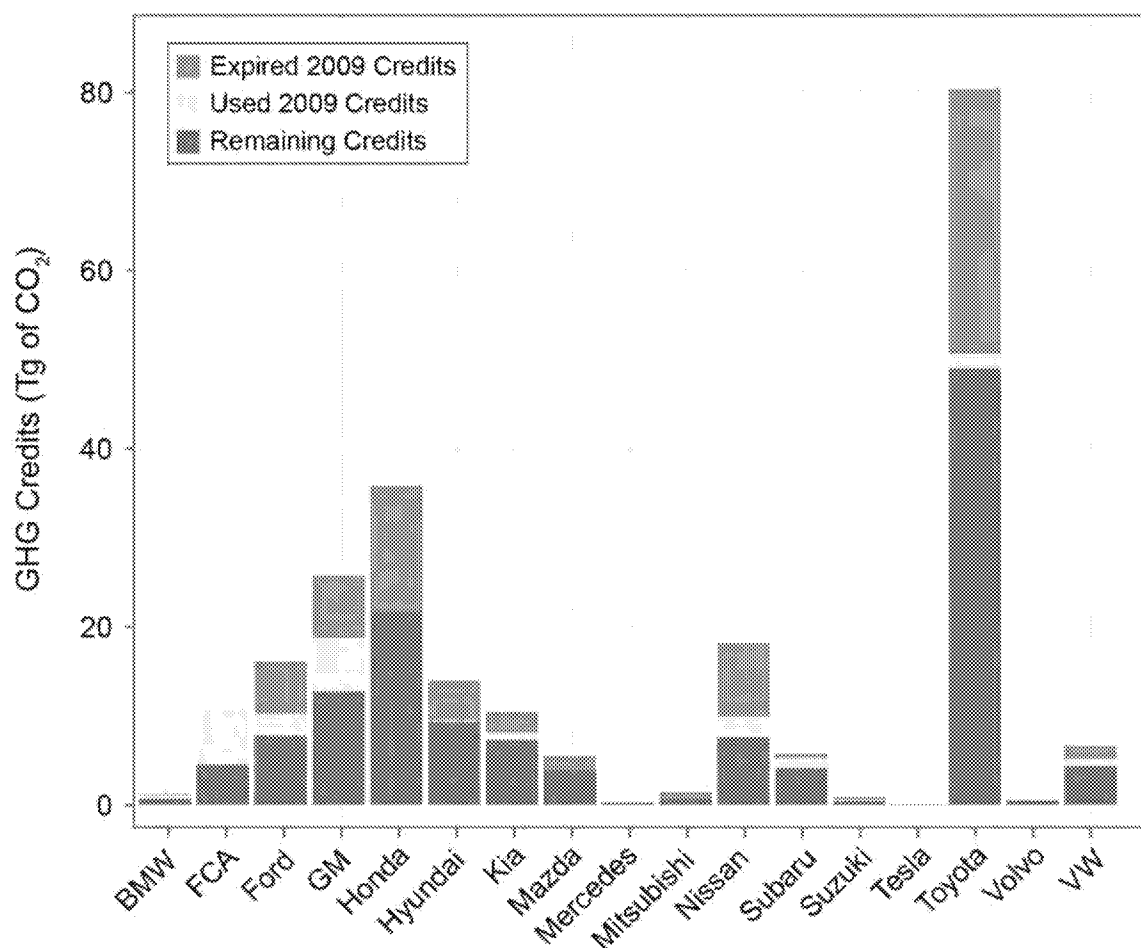
Of the 234 Tg of early credits, 85% of those credits were generated from performing better than the tailpipe CO_2 emissions targets established in the regulations. About 10% were due to A/C leakage credits, 4% were due to A/C efficiency improvements, and just over 1% were due to off-cycle credits. Manufacturers can no longer generate early credits. More details of the early credit program can be found in the "Early Credits Report," which was released by EPA in 2013.[22]

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[22] Greenhouse Gas Emission Standards for Light-Duty Automobiles: Status of Early Credit Program for Model Years 2009-2011, Compliance Division, Office of Transportation and Air Quality, U.S. Environmental Protection Agency, Report No. EPA-420-R-13-005, March 2013.

Model Year Performance Versus Standards

Manufacturer-specific standards and performance within the model year were discussed in Sections 5.A and 5.B above. Comparing these two values for each manufacturer's fleet determines the annual net compliance for each fleet. The total credit surplus or shortfall for that model year is determined by manufacturers based on the net compliance and total production of each fleet.

Figure 5.14 illustrates the performance of the large manufacturers in model year 2018, compared to their standards, and prior to the application of banked credits from previous model years or credit transactions between companies. As explained previously, manufacturers have separate car and truck standards, and do not have an overall standard. However, it is useful to calculate and show an equivalent overall standard for evaluating a manufacturer's overall status under the GHG program.

Figure 5.14 is a "snapshot" that shows how manufacturers performed against the standards with their 2018 fleets, but it does not portray whether these manufacturers have ultimately complied with the model year 2018 standards. Most large manufacturers were above (i.e., did not meet) their standard in model year 2018. As with model year 2017, only three of the 14 large manufacturers were able to achieve compliance based on the emission performance of their 2018 model year vehicles, without utilizing additional banked credits. Two of those are the same as last year—Honda and Subaru. Unlike with the 2017 model year, BMW did not achieve compliance based upon emission performance for the 2018 model year. The third manufacturer to meet compliance based upon emissions performance is Tesla, which became a large volume manufacturer for the first time for the 2018 model year. The fact that manufacturers were above their standards does not mean that these manufacturers were out of compliance with the GHG program, as all of these manufacturers had or acquired more than enough credits to offset the difference, as shown later in this report. While most individual manufacturers were above their individual standards, on average the industry only missed the standards by 1 g/mile and achieved the lowest fleetwide performance of any year of the program thus far.

Figure 5.14. Performance and Standards by Manufacturer, 2018 Model Year
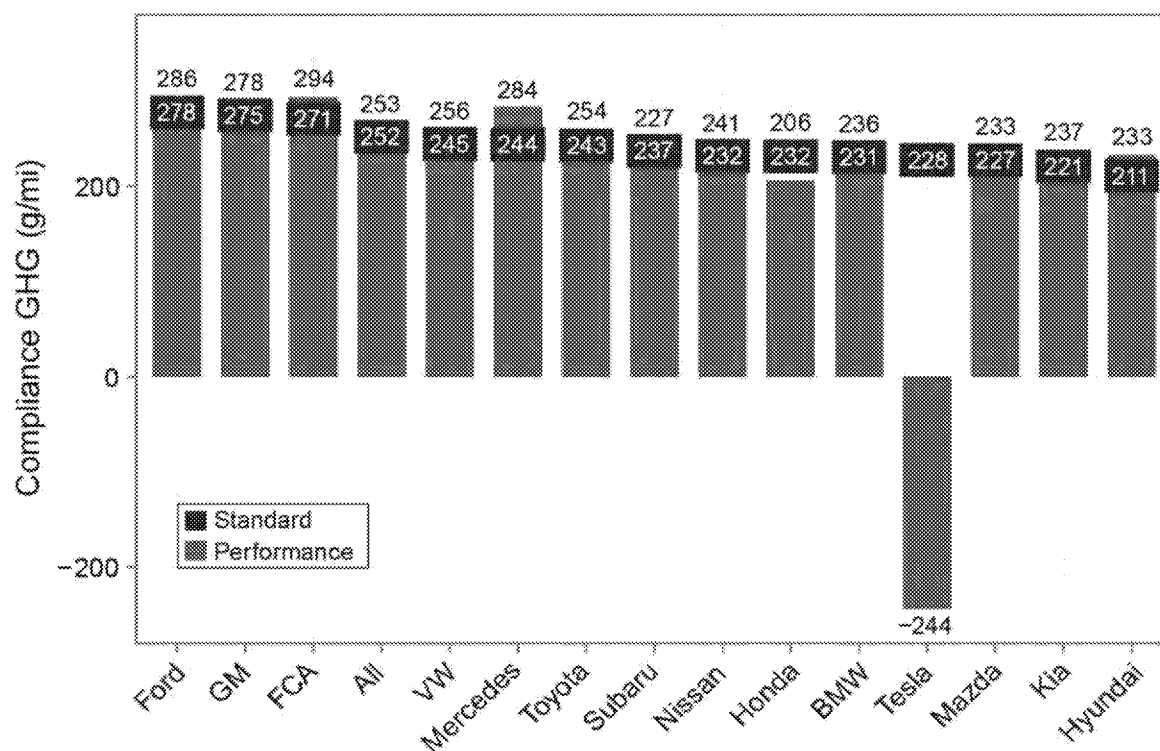
Table 5.11 through Table 5.16 provide a summary of the standards, manufacturer performance, and net compliance by manufacturer for model year 2018, and for the aggregated industry for model years 2009–2018 (including early credits). The net compliance value is the difference between the standard and performance value. A negative value indicates that the manufacturer, or the industry, was below the applicable standard and generated credits. Conversely, a positive net compliance value indicates that the manufacturer, or the industry, exceeded (i.e., did not meet) the standards and generated a credit shortfall.

Toyota, for example, generated a 2018 model year credit shortfall because their overall compliance value of 254 g/mi is above their fleet-wide standard of 243 g/mi. Honda, on the other hand, reported a credit surplus based on a compliance value of 206 g/mi, 26 g/mi lower than their fleet-wide standard of 232 g/mi.

These tables only show credits generated within a model year, and do not account for credits used to offset deficits in other model years, credits that are traded between manufacturers, or credits that have expired or been forfeited. It is important to note that the tables showing combined results are aggregated from the passenger car and light-duty truck data and standards; there are no independent standards for the combined fleet.

Table 5.11. Credits Earned by Manufacturers in Model Year 2018, All

Manufacturer	Performance Value (g/mi)	Standard (g/mi)	Net Compliance (g/mi)	Production	Credit Surplus/ Shortfall (Mg)
BMW	236	231	5	368,192	-416,713
BYD Motors	-215	215	-430	2	168
FCA	294	271	23	1,888,041	-9,396,315
Ford	286	278	8	2,103,253	-3,762,524
GM	278	275	3	2,669,227	-1,929,023
Honda	206	232	-26	1,626,866	8,598,273
Hyundai	233	211	22	708,227	-3,011,849
Jaguar Land Rover	283	283	0	110,615	-4,901
Kia	237	221	16	509,318	-1,649,692
Mazda	233	227	6	318,835	-385,089
Mercedes	284	244	40	362,680	-2,974,379
Mitsubishi	213	221	-8	126,438	203,923
Nissan	241	232	9	1,327,744	-2,567,935
Subaru	227	237	-10	674,395	1,533,010
Tesla	-244	228	-472	193,102	17,869,526
Toyota	254	243	11	2,443,132	-5,617,632
Volkswagen	256	245	11	729,483	-1,729,374
Volvo	245	283	-38	94,944	791,296
All Manufacturers	**253**	**252**	**1**	**16,254,494**	**-4,449,230**

Table 5.12. Total Credits Earned in Model Years 2009–2018, All

Model Year	Performance Value (g/mi)	Standard (g/mi)	Net Compliance (g/mi)	Production	Credit Surplus/ Shortfall (Mg)	Credit Expiration
2009	-	-	-	-	98,520,511	2014
2010	-	-	-	-	96,890,664	2021
2011	-	-	-	-	38,769,164	2021
2012	287	299	-12	13,345,155	33,013,724	2021
2013	278	292	-14	15,103,066	42,627,850	2021
2014	273	287	-14	15,478,831	43,325,498	2021
2015	267	274	-7	16,677,789	25,095,159	2021
2016	271	263	8	16,276,424	-27,721,443	2021
2017	263	258	5	17,010,779	-16,600,603	2022
2018	253	252	1	16,254,494	-4,449,230	2023

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Table 5.13. Credits Earned by Manufacturers in Model Year 2018, Car

Manufacturer	Performance Value (g/mi)	Standard (g/mi)	Net Compliance (g/mi)	Production	Credit Surplus/ Shortfall (Mg)
BMW	223	212	11	269,666	-561,953
BYD Motors	-215	215	-430	2	168
FCA	278	220	58	370,666	-4,227,633
Ford	231	210	21	721,024	-2,918,968
GM	205	209	-4	992,131	753,552
Honda	182	208	-26	1,032,136	5,183,156
Hyundai	229	209	20	686,103	-2,703,395
Jaguar Land Rover	244	244	0	12,059	680
Kia	217	207	10	402,888	-770,573
Mazda	221	206	15	203,821	-582,325
Mercedes	255	217	38	208,832	-1,556,906
Mitsubishi	186	192	-6	58,412	63,840
Nissan	210	207	3	895,716	-560,324
Subaru	236	202	34	150,547	-1,001,931
Tesla	-241	225	-466	186,290	16,938,526
Toyota	198	207	-9	1,243,916	2,110,765
Volkswagen	237	206	31	329,216	-1,973,519
Volvo	227	252	-25	24,177	120,015
All Manufacturers	**204**	**209**	**-5**	**7,787,602**	**8,313,175**

Table 5.14. Total Credits Earned in Model Years 2009–2018, Car

Model Year	Performance Value (g/mi)	Standard (g/mi)	Net Compliance (g/mi)	Production	Credit Surplus/ Shortfall (Mg)	Credit Expiration
2009	-	-	-	-	58,017,205	2014
2010	-	-	-	-	50,856,024	2021
2011	-	-	-	-	8,830,528	2021
2012	249	266	-17	8,628,026	30,564,873	2021
2013	240	260	-20	9,722,724	39,290,512	2021
2014	236	253	-17	9,197,604	30,447,846	2021
2015	230	241	-11	9,597,167	22,061,932	2021
2016	229	231	-2	8,998,957	3,373,702	2021
2017	217	219	-2	8,936,169	2,602,721	2022
2018	204	209	-5	7,787,602	8,313,175	2023

Table 5.15. Credits Earned by Manufacturers in Model Year 2018, Truck

Manufacturer	Performance Value (g/mi)	Standard (g/mi)	Net Compliance (g/mi)	Production	Credit Surplus/ Shortfall (Mg)
BMW	268	275	-7	98,526	145,240
FCA	297	282	15	1,517,375	-5,168,682
Ford	311	308	3	1,382,229	-843,556
GM	315	308	7	1,677,096	-2,682,575
Honda	242	267	-25	594,730	3,415,117
Hyundai	328	266	62	22,124	-308,454
Jaguar Land Rover	287	287	0	98,556	-5,581
Kia	304	267	37	106,430	-879,119
Mazda	252	260	-8	115,014	197,236
Mercedes	317	276	41	153,848	-1,417,473
Mitsubishi	233	242	-9	68,026	140,083
Nissan	298	277	21	432,028	-2,007,611
Subaru	225	246	-21	523,848	2,534,941
Tesla	-313	292	-605	6,812	931,000
Toyota	304	275	29	1,199,216	-7,728,397
Volkswagen	269	272	-3	400,267	244,145
Volvo	250	292	-42	70,767	671,281
All Manufacturers	**292**	**286**	**6**	**8,466,892**	**-12,762,405**

Table 5.16. Total Credits Earned in Model Years 2009–2018, Truck

Model Year	Performance Value (g/mi)	Standard (g/mi)	Net Compliance (g/mi)	Production	Credit Surplus/ Shortfall (Mg)	Credit Expiration
2009	-	-	-	-	40,503,306	2014
2010	-	-	-	-	46,034,640	2021
2011	-	-	-	-	29,938,636	2021
2012	346	346	-	4,717,129	2,448,851	2021
2013	337	337	-	5,380,342	3,337,338	2021
2014	321	330	-9	6,281,227	12,877,652	2021
2015	310	311	-1	7,080,622	3,033,227	2021
2016	315	297	18	7,277,467	-31,095,145	2021
2017	306	295	11	8,074,610	-19,203,324	2022
2018	292	286	6	8,466,892	-12,762,405	2023

Credit Transactions

Credits may be traded among manufacturers with a great deal of flexibility. There are only a few regulatory requirements that relate to credit transactions between manufacturers, and these are generally designed to protect those involved in these transactions. While it may seem obvious, it is worth stating that a manufacturer may not trade credits that it does not have. Credits that are available for trade are only those available (1) at the end of a model year, and (2) after a manufacturer has offset any deficits they might have. Credit transactions that result in a negative credit balance for the selling manufacturer are not allowed. Although a third party may facilitate transactions, EPA's regulations allow only the automobile manufacturers to engage in credit transactions and hold credits.

The credit transactions reported by manufacturers through the 2018 model year are summarized in Figure 5.15. Credits that have been sold are shown as negative credits, since the sale of credits will reduce the selling manufacturer's credit balance. Conversely, credits that have been purchased are shown as positive credits, since they will increase the purchasing manufacturer's credit balance. The values shown in Figure 5.15 are the total quantity of credits that have been bought or sold by a manufacturer, and likely represent multiple transactions between various manufacturers. Figure 5.15 also shows the expiration date of credits sold and acquired. Credits generated in model years 2017 and 2018 have a life of 5 years and will thus expire in 2022 and 2023, respectively. All other credits will expire in model year 2021. As of the close of the 2018 model year, about 66 Tg of CO_2 credits had changed hands.

Note that manufacturers are not required to report transactions to EPA as they occur; thus, there may be additional credit transactions that have occurred that are not reported here. Transactions reported after the manufacturers submitted their model year 2018 data will be reported in the next release of this report.

Figure 5.15. Total Credits Transactions Through Model Year 2018
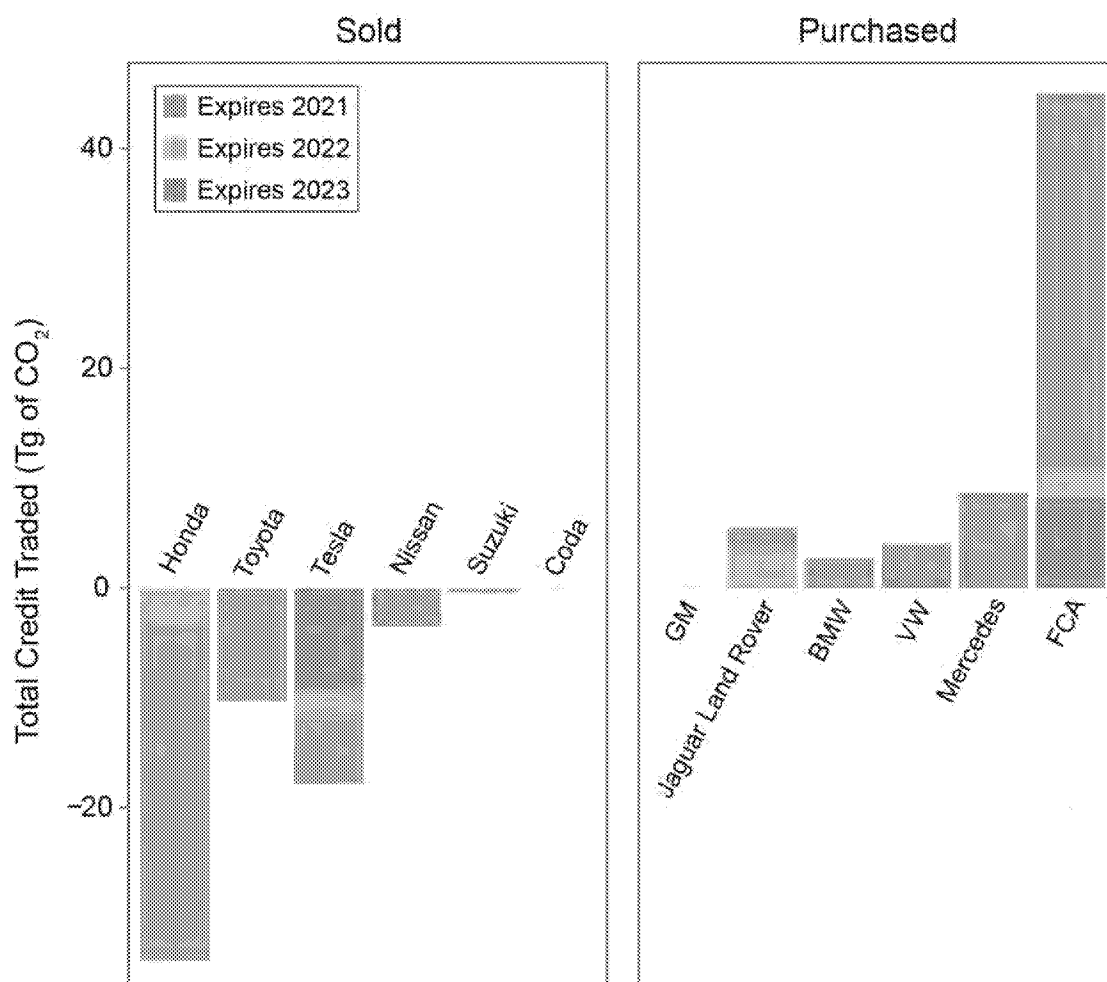
Final Credit Balances

At the end of each model year, manufacturers calculate their total credit balance. The final credit balance is the sum of prior credits or deficits, credit surpluses or shortfalls accrued in the current model year, expired or forfeited credits, and credits purchased or sold. Table 5.17 shows the impact of each of these categories for each manufacturer, including their final model year 2018 credit balances. Table 5.18 shows the breakdown of expiration dates for credit balances, and the distribution, by age, of credit deficits. All credit deficits must be offset within three years, or a manufacturer will be considered non-compliant with the GHG program.

Table 5.17. Final Credit Balance by Manufacturer for Model Year 2018 (Mg)

Manufacturer	Early Credits Earned 2009-2011	Credits Earned 2012-2017	Credits Earned 2018	Credits Expired	Credits Forfeited	Credits Purchased or Sold*	Final 2018 Credit Balance
BMW	1,251,522	224,909	-416,713	-134,791	-	5,500,000	6,424,927
BYD Motors	-	5,400	168	-	-	-	5,568
Coda	-	7,251	-	-	-	-7,251	-
FCA	10,827,083	-22,967,481	-9,396,315	-	-	45,054,999	23,518,286
Ford	16,116,453	6,154,294	-3,762,524	-5,882,011	-	-	12,626,212
GM	25,788,547	1,216,402	-1,929,023	-6,998,699	-	7,251	18,084,478
Honda	35,842,334	44,423,035	8,598,273	-14,133,353	-	-34,245,245	40,485,044
Hyundai	14,007,495	8,833,667	-3,011,849	-4,482,649	-169,775	-	15,176,889
Jaguar Land Rover	-	-2,869,661	-4,901	-	-	2,722,736	-151,826
Karma Automotive	-	58,852	-	-	-	-2,841	56,011
Kia	10,444,192	-2,990,314	-1,649,692	-2,362,882	-123,956	-	3,317,348
Mazda	5,482,642	6,335,942	-385,089	-1,340,917	-	-	10,092,578
Mercedes	378,272	-6,004,114	-2,974,379	-	-28,416	8,727,713	99,076
Mitsubishi	1,449,336	1,227,844	203,923	-583,146	-	0	2,297,957
Nissan	18,131,200	19,527,625	-2,567,935	-8,190,124	-	-3,545,570	23,355,196
Porsche	-	426,439	-	-	-426,439	-	-
Subaru	5,755,171	11,636,165	1,533,010	-491,789	-	-	18,432,557
Suzuki	876,650	-183,097	-	-265,311	-	-428,242	-
Tesla	49,772	10,870,056	17,869,526	-	-	-17,831,311	10,958,043
Toyota	80,435,498	28,579,728	-5,617,632	-29,732,098	-	-10,262,431	63,403,065
Volkswagen	6,613,985	-4,247,836	-1,729,374	-1,442,571	-219,419	4,000,000	2,974,785
Volvo	730,187	-380,789	791,296	-	-85,163	-	1,055,531
All Manufacturers	**234,180,339**	**99,884,317**	**-4,449,230**	**-76,040,341**	**-1,053,168**	**(310,192)**	**252,211,725**

* The transactions do not net to zero due to transactions with small volume manufacturers excluded from this report.

Table 5.18. Distribution of Credits by Expiration Date (Mg)

Manufacturer	Final 2018 Credit Balance	Credits Expiring in 2021	Credits Expiring in 2022	Credits Expiring in 2022	Deficit Carried 1 year	Deficit Carried 2 years
BMW	6,424,927	2,623,676	3,656,011	145,240		
BYD Motors	5,568	4,871	529	168		
FCA	23,518,286	12,870,920	2,419,871	8,227,495		
Ford	12,626,212	12,626,212	0	0		
GM	18,084,478	15,044,507	2,286,419	753,552		
Honda	40,485,044	27,814,774	4,071,997	8,598,273		
Hyundai	15,176,889	15,176,889	0	0		
Jaguar Land Rover	-151,826	0	0	0	-5,581	-146,245
Karma Automotive	56,011	56,011	0	0		
Kia	3,317,348	3,317,348	0	0		
Mazda	10,092,578	9,724,291	171,051	197,236		
Mercedes	99,076	99,076	0	0		
Mitsubishi	2,297,957	1,922,105	171,929	203,923		
Nissan	23,355,196	22,846,419	508,777	0		
Subaru	18,432,557	12,706,379	3,191,237	2,534,941		
Tesla	10,958,043	0	2,316,012	8,642,031		
Toyota	63,403,065	59,063,588	2,228,712	2,110,765		
Volkswagen	2,974,785	1,730,640	0	1,244,145		
Volvo	1,055,531	0	264,235	791,296		
All Manufacturers	**252,211,725**	**197,627,706**	**21,286,780**	**33,449,065**	**-5,581**	**-146,245**

D. Compliance Status After the 2018 Model Year

To evaluate the overall compliance status of manufacturers, EPA considers the credit balance of each manufacturer at the end of the most recent model year. Because credits may not be carried forward unless deficits from all prior model years have been resolved, a positive credit balance means compliance with the current and all previous model years of the program. The credits accrued will be available to that manufacturer until they are used to offset a credit shortfall within a future model year, or until they expire. Figure 5.16 (and Table 5.17) show the credit balance of all manufacturers after model year 2018.

Figure 5.16. Manufacturer Credit Balance After Model Year 2018

Manufacturers with a positive credit balance have complied through Model Year 2018

Manufacturers with a negative credit balance have up to 3 years to offset the deficit

GHG Credits (Tg of CO_2)
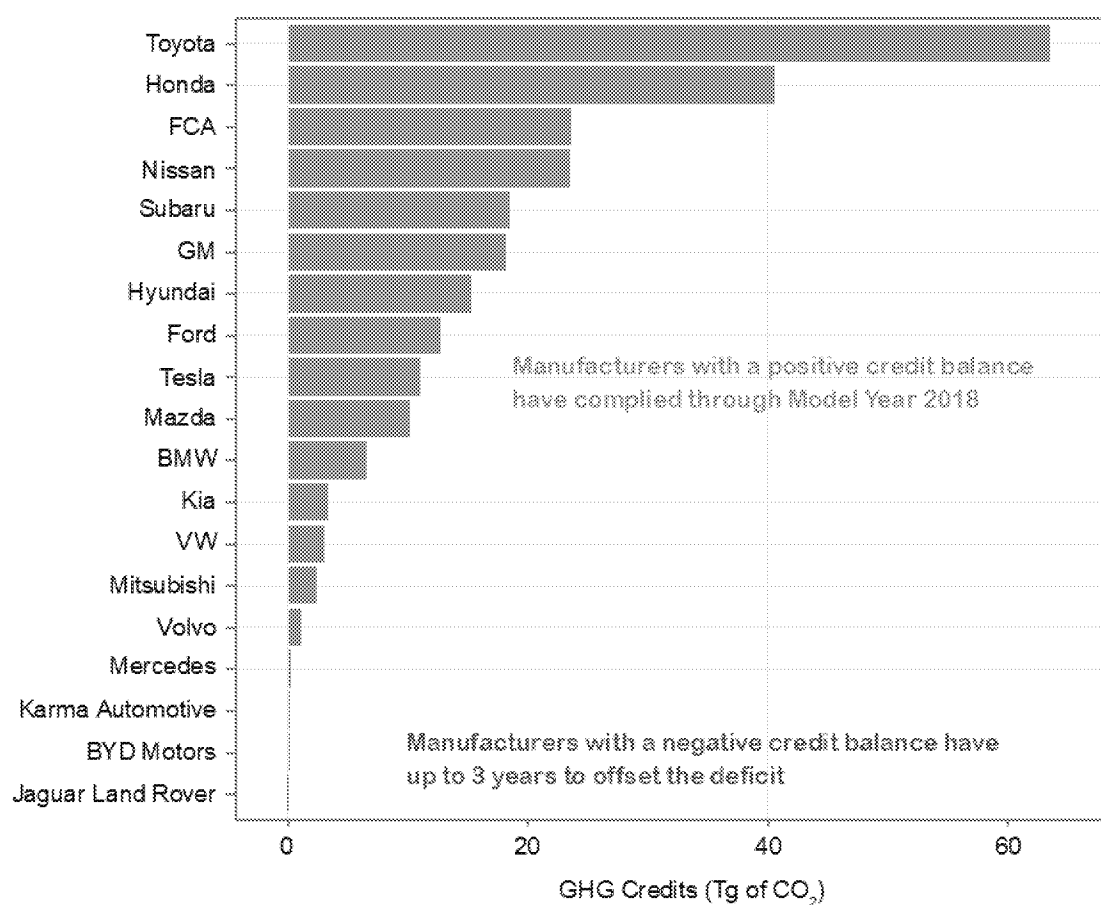
All manufacturers, except one, ended the 2018 model year with a positive credit balance and are thus in compliance with model year 2018 and all previous years of the GHG program. Jaguar Land Rover, the sole manufacturer carrying a deficit into the 2019 model year, does not have any outstanding deficits that would result in noncompliance or

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enforcement actions from EPA. However, Jaguar Land Rover will have to offset the existing deficits in future model years either by producing future efficient vehicles that exceed the standards, or by purchasing credits from other manufacturers.

Figure 5.17 shows the overall industry performance, standards, and credit bank for all years of the GHG program. As discussed earlier in this section, the performance of the industry on average was below the standards for the first four years of the GHG program, from model year 2012 through 2015. In model years 2016 through 2018, the industry was on average above the standards. In model year 2018 the industry improved overall GHG performance by 10 g/mi, and while this was not quite enough to meet the standard, the gap between the GHG standard and fleet average performance narrowed to a very slim margin of 1 g/mi.

The industry created a large bank of credits using the early credits provision and it continued to grow the bank of credits during the first four years of the program by reducing emissions below the requirements of the standards. For the last three years, the industry has had to use banked credits, reducing the overall credit bank, but the balance of credits remains substantial, and is practically unchanged after the 2018 model year.

The industry emerges from model year 2018 with a bank of 252 teragrams (Tg) of GHG credits to draw upon in future years. Based on their compliance strategy, many manufacturers used credits in model year 2018. As a result, the industry depleted their collective credit bank by about 4.5 Tg, or about 2% of the total credit balance, to maintain compliance. If applied entirely to model year 2018, the balance of 252 Tg would be equivalent to a fleetwide GHG reduction of about 74 g/mi. Of those credits, about 80% will expire at the end of model year 2021 if not used.

After accounting for the use of credits, and the ability to carry forward a deficit in the case of Jaguar Land Rover, the industry overall does not face any non-compliance issues as of the end of the 2018 model year.

Figure 5.17. Industry Performance and Standards, Credit Generation and Use
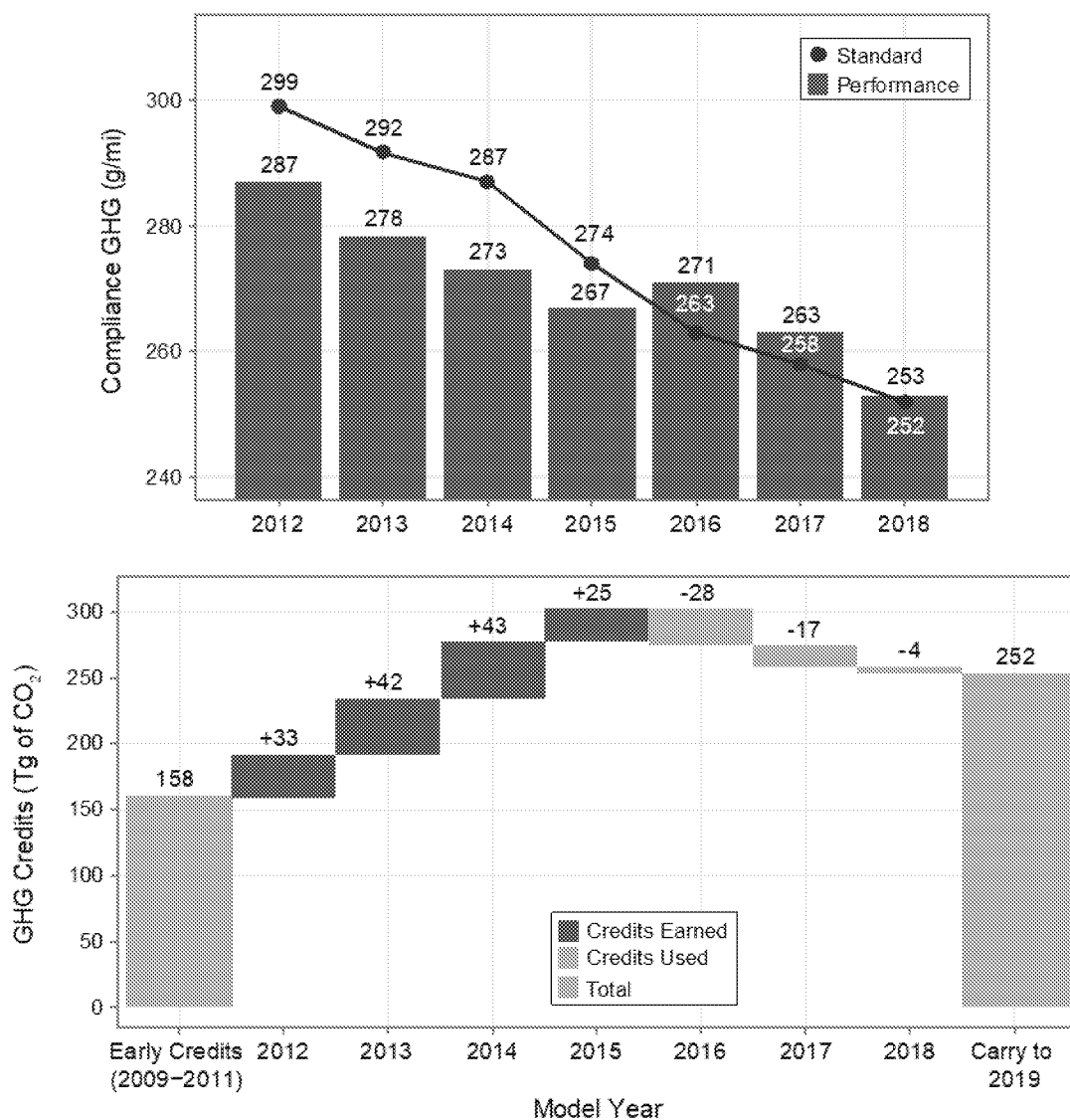
Appendices: Methods and Additional Data

A. Sources of Input Data

Nearly all of the data for this report are based on automakers' direct submissions to EPA. EPA has required manufacturers to provide vehicle fuel economy to consumers since 1977, and has collected data on every new light-duty vehicle model sold in the United States since 1975. The data are obtained either from testing performed by EPA at the National Vehicle and Fuel Emissions Laboratory in Ann Arbor, Michigan, or directly from manufacturers using official EPA test procedures.

National fuel economy standards have been in place in the United States for cars and light trucks since 1978. The Department of Transportation, through the National Highway Traffic Safety Administration (NHTSA), has the responsibility for setting and enforcing fuel economy standards through the Corporate Average Fuel Economy (CAFE) program. Since the inception of CAFE, EPA has been responsible for establishing test procedures and calculation methods, and for collecting data used to determine vehicle fuel economy levels. EPA calculates the CAFE value for each manufacturer and provides it to NHTSA. NHTSA publishes the final CAFE values in its annual "Summary of Fuel Economy Performance" reports at www.nhtsa.gov/Laws-&-Regulations/CAFE---Fuel-Economy. Since model year 2012, NHTSA and EPA have maintained coordinated fuel economy and greenhouse gas standards that apply to model year 2012 through model year 2025[42] vehicles.

The data that EPA collects comprise the most comprehensive database of its kind. For recent model years, the vast majority of the data in this report are reported to EPA using the EV-CIS database maintained by EPA. This database contains a broad amount of data associated with CO_2 emissions and fuel economy, vehicle and engine technology, and other vehicle performance metrics. This report extracts only a portion of the data from the EV-CIS database.

In some cases, the data submitted by automakers are supplemented by data that were obtained through independent research by EPA. For example, EPA relied on published data from external sources for certain parameters of pre-model year 2011 vehicles: (1) engines with variable valve timing (VVT), (2) engines with cylinder deactivation, and (3) vehicle footprint, as automakers did not submit this data until model year 2011. EPA projects footprint data for the preliminary model year 2019 fleet based on footprint values for

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[42] See 75 Federal Register 25324, May 7, 2010 and 77 Federal Register 62624, October 15, 2012.

existing models from previous years and footprint values for new vehicle designs available through public sources. In addition, vehicle 0-to-60 acceleration values are not provided by automakers, but are either calculated from other Trends data, as discussed in Section 3, or taken from external sources.

This report presents analysis and data drawn from the extensive Trends database. The website for this report has been expanded with an emphasis on allowing users to access and evaluate more of the data behind this report. EPA plans to continue to add content and tools on the web to allow transparent access to public data. All public data available on the web can be accessed at the following links:

- Explore data with interactive figures and download data from Supplemental Data Tables supplied in previous reports here: https://www.epa.gov/automotive-trends/explore-automotive-trends-data.

- Download report tables here: https://www.epa.gov/automotive-trends/download-automotive-trends-report.

The full Trends database is not publicly available. The detailed production data necessary for demonstrating compliance is considered confidential business information by the manufacturers and cannot be shared by EPA. However, EPA will continue to provide as much information as possible to the public.

Preliminary vs Final Data

For each model year, automakers submit two phases of data: **preliminary data** provided to EPA for vehicle certification and labeling prior to the model year sales, and **final data** submitted after the completion of the model year for compliance with EPA's light-duty GHG regulations and NHTSA's CAFE program.

Preliminary data are collected prior to the beginning of each model year and are not used for manufacturer GHG compliance. Automakers submit "General Label" information required to support the generation of the joint EPA/NHTSA Fuel Economy and Environment Labels that appear on all new personal vehicles. As part of these submissions, automakers report pre-model year vehicle production projections for individual models and configurations to EPA.

Final data are submitted a few months after the end of each model year and include detailed final production volumes. EPA and NHTSA use this final data to determine compliance with GHG emissions and CAFE standards. These end-of-the-year submissions include detailed final production volumes. All data in this report for model years 1975

through 2018 are considered final. However, manufacturers can submit requests for compliance credits for previous model years, so it is possible that additional credits under the GHG program could be awarded to manufacturers.

Since the preliminary fuel economy values provided by automakers are based on projected vehicle production volumes, they usually vary slightly from the final fuel economy values that reflect the actual sales at the end of the model year. With each publication of this report, the preliminary values from the previous year are updated to reflect the final values. This allows a comparison to gauge the accuracy of preliminary projections.

Table A.1 compares the preliminary and final fleetwide real-world fuel economy values for recent years (note that the differences for CO_2 emissions data would be similar, on a percentage basis). Since model year 2011, the final real-world fuel economy values have generally been close to the preliminary fuel economy values. In six out of the last seven years, manufacturer projections have led to preliminary estimates that were higher than final data. This could be due to many reasons, but lower than expected gasoline costs and the increasing percentage of SUVs purchased by consumers likely contributed to this overestimation.

It is important to note that there is no perfect apples-to-apples comparison for model years 2011–2014 due to several small data issues, such as alternative fuel vehicle (AFV) data. The preliminary values in Table A.1 through model year 2014 did not integrate AFV data, while the final values in Table A.1 are the values reported elsewhere in this report and do include AFV data. The differences due to this would be small, on the order of 0.1 mpg or less.

Table A.1. Comparison of Preliminary and Final Real-World Fuel Economy Values (mpg)

Model Year	Preliminary Value	Final Value	Final Minus Preliminary
2011	22.8	22.3	-0.5
2012	23.8	23.6	-0.2
2013	24.0	24.2	+0.2
2014	24.2	24.1	-0.1
2015	24.7	24.6	-0.2
2016	25.6	24.7	-0.9
2017	25.2	24.9	-0.3
2018	25.4	25.1	-0.3
2019 (prelim)	25.5	-	-

B. Harmonic Averaging of Fuel Economy Values

Averaging multiple fuel economy values must be done harmonically in order to obtain a correct mathematical result. Since fuel economy is expressed in miles per gallon (mpg), one critical assumption with any harmonic averaging of multiple fuel economy values is whether the distance term (miles, in the numerator of mpg) is fixed or variable. This report makes the assumption that the distance term in all mpg values is fixed, i.e., that for purposes of calculating a harmonically averaged fuel economy value, it is assumed that the distance term (representing miles traveled) is equivalent across various vehicle fuel economies. This assumption is the standard practice with harmonic averaging of multiple fuel economy values (including, for example, in calculations for CAFE standards compliance), and simplifies the calculations involved.

Mathematically, when assuming a fixed distance term as discussed above, harmonic averaging of multiple fuel economy values can be defined as the inverse of the average of the reciprocals of the individual fuel economy values. It is best illustrated by a simple example.

Consider a round trip of 600 miles. For the first 300-mile leg, the driver is alone with no other passengers or cargo, and, aided by a tailwind, uses 10 gallons of gasoline, for a fuel economy of 30 mpg. On the return 300-mile trip, with several passengers, some luggage, and a headwind, the driver uses 15 gallons of gasoline, for a fuel economy of 20 mpg. Many people will assume that the average fuel economy for the entire 600-mile trip is 25 mpg, the arithmetic (or simple) average of 30 mpg and 20 mpg. But, since the driver consumed 10 + 15 = 25 gallons of fuel during the trip, the actual fuel economy is 600 miles divided by 25 gallons, or 24 mpg.

Why is the actual 24 mpg less than the simple average of 25 mpg? Because the driver used more gallons while (s)he was getting 20 mpg than when (s)he was getting 30 mpg.

This same principle is often demonstrated in elementary school mathematics when an airplane makes a round trip, with a speed of 400 mph one way and 500 mph the other way. The average speed of 444 mph is less than 450 mph because the airplane spent more time going 400 mph than it did going 500 mph.

As in both of the examples above, a harmonic average will typically yield a result that is slightly lower than the arithmetic average.

The following equation illustrates the use of harmonic averaging to obtain the correct mathematical result for the fuel economy example above:

$$\text{Average mpg} = \frac{2}{\left(\frac{1}{30} + \frac{1}{20}\right)} = 24 \text{ mpg}$$

Thought the above example was for a single vehicle with two different fuel economies over two legs of a single round trip, the same mathematical principle holds for averaging the fuel economies of any number of vehicles. For example, the average fuel economy for a set of 10 vehicles, with three 30 mpg vehicles, four 25 mpg vehicles, and three 20 mpg vehicles would be (note that, in order to maintain the concept of averaging, the total number of vehicles in the numerator of the equation must equal the sum of the individual numerators in the denominator of the equation):

$$\text{Average mpg} = \frac{10}{\left(\frac{3}{30} + \frac{4}{25} + \frac{3}{20}\right)} = 24.4 \text{ mpg}$$

Arithmetic averaging, not harmonic averaging, provides the correct mathematical result for averaging fuel consumption values (in gallons per mile, the inverse of fuel economy) and CO_2 emissions (in grams per mile). In the first, round trip, example above, the first leg had a fuel consumption rate of 10 gallons over 300 miles, or 0.033 gallons per mile. The second leg had a fuel consumption of 15 gallons over 300 miles, or 0.05 gallons per mile. Arithmetically averaging the two fuel consumption values, i.e., adding them up and dividing by two, yields 0.04167 gallons per mile, and the inverse of this is the correct fuel economy average of 24 mpg. Arithmetic averaging also works for CO_2 emissions values, i.e., the average of 200 g/mi and 400 g/mi is 300 g/mi CO_2 emissions.

In summary, fuel economy values must be harmonically averaged to maintain mathematical integrity, while fuel consumption values (in gallons per mile) and CO_2 emissions values (in grams per mile) can be arithmetically averaged.

C. Fuel Economy and CO_2 Metrics

The CO_2 emissions and fuel economy data in this report fall into one of two categories: **compliance data** and **estimated real-world data**. These categories are based on the purpose of the data, and the subsequent required emissions test procedures. The following sections discuss the differences between compliance and real-world data and how they relate to raw vehicle emissions test results.

2-Cycle Test Data

In 1975 when the Corporate Average Fuel Economy (CAFE) regulation was put into place, EPA tested vehicles using two dynamometer-based test cycles, one based on city driving and one based on highway driving. CAFE was—and continues to be—required by law to use these "2-cycle tests". For consistency, EPA also adopted this approach for the GHG regulations.

Originally, the fuel economy values generated from the "2-cycle" test procedure were used both to determine compliance with CAFE requirements and to inform consumers of their expected fuel economy via the fuel economy label. Today, the raw 2-cycle test data are used primarily in a regulatory context as the basis for determining the final compliance values for CAFE and GHG regulations.

The 2-cycle testing methodology has remained largely unchanged[43] since the early 1970s. Because of this, the 2-cycle fuel economy and CO_2 values can serve as a useful comparison of long-term trends. Previous versions of this report included 2-cycle fuel economy and CO_2 data, referred to as "unadjusted" or "laboratory" values. These 2-cycle fuel economy values are still available on the report website and in Appendix D for reference. It is important to note that these 2-cycle fuel economy values do not exactly correlate to the 2-cycle tailpipe CO_2 emissions values provided in Section 5 for the GHG regulations. There are three methodological reasons for this:

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[43] There were some relatively minor test procedure changes made in the late 1970s that, in the aggregate, made the city and highway tests slightly more demanding, i.e., the unadjusted fuel economy values for a given car after these test procedure changes were made are slightly lower relative to prior to the changes. EPA has long provided CAFE "test procedure adjustments" (TPAs) for passenger cars in recognition of the fact that the original CAFE standards were based on the EPA test procedures in place in 1975 (there are no TPAs for light trucks). The resulting impacts on the long-term unadjusted fuel economy trends are very small. The TPAs for cars vary but are typically in the range of 0.2–0.5 mpg for cars, or 0.1–0.3 mpg when the car TPAs are averaged over the combined car/truck fleet.

1. The GHG regulations require a car and truck weighting based on a slightly higher lifetime vehicle miles traveled (VMT) for trucks. The 2-cycle fuel economy values do not account for this difference.
2. The GHG regulations allow manufacturers to use an optional compliance approach which adds nitrous oxide and methane emissions to their 2-cycle CO_2 emissions.
3. The GHG regulations and CAFE regulations result in very slightly different annual production values. Prior to model year 2017, the 2-cycle fuel economy values rely on CAFE production values (see Appendix D).

GHG Compliance Data

Compliance data in this report are used to determine how the manufacturers are performing under EPA's GHG program. These data are reported in the Executive Summary and Section 5. The 2-cycle CO_2 test values form the basis for the compliance data, but there are some important differences due to provisions in the standards. Manufacturers' model year performance is calculated based on the measured 2-cycle CO_2 tailpipe emissions and flexibilities that manufacturers may qualify for and use.

Compliance data also includes the overall credit balances held by each manufacturer, and may incorporate credit averaging, banking, and trading by manufacturers. The compliance process is explained in detail in Section 5. Compliance CO_2 data is not comparable to estimated real-world CO_2 data, as described below.

Estimated Real-World Fuel Economy and CO_2 Data

Estimated real-world (previously called "adjusted") data is EPA's best estimate of real-world fuel economy and CO_2 emissions, as reported in Sections 1–4 of this report. The real-world values are the best data for researchers to evaluate new vehicle CO_2 and fuel economy performance. Unlike compliance data, the method for calculating real-world data have evolved over time, along with technology and driving habits. These changes in methodology are detailed in Appendix D.

Calculating estimated real-world fuel economy

Estimated real-world fuel economy data are currently measured based on the "5-cycle" test procedure that utilizes high-speed, cold start, and air conditioning tests in addition to the 2-cycle tests to provide data more representative of real-world driving. These additional laboratory tests capture a wider range of operating conditions (including hot/cold weather and higher acceleration) that an average driver will encounter. City and highway results are weighted 43% / 57%, consistent with fleetwide driver activity data.

Calculating estimated real-world CO_2 emissions

The estimated real-world CO_2 emissions shown in Sections 1–4 are not based directly on the 2-cycle tested values, but rather they are based on calculated values that convert estimated real-world fuel economy values to CO_2 using emission factors. This approach is taken because: 1) test data are not available for most historic years of data, and 2) some manufacturers choose to use an optional compliance approach which adds nitrous oxide (N_2O) and methane (CH_4) emissions to their CO_2 emissions (also referred to as Carbon Related Exhaust Emissions, or CREE), leading to slightly different test results.

The estimated real-world CO_2 emissions from gasoline vehicles are calculated by dividing 8,887 g/gal by the fuel economy of the vehicle. The 8,887 g/gal emission factor is a typical value for the grams of CO_2 per gallon of gasoline test fuel, and assumes all the carbon is converted to CO_2. For example, 8,887 g/gal divided by a gasoline vehicle fuel economy of 30 mpg would yield an equivalent CO_2 emissions value of 296 grams per mile.

The estimated real-world CO_2 emissions for diesel vehicles are calculated by dividing 10,180 g/gal by the diesel vehicle fuel economy value. The 10,180 g/gal diesel emission factor is higher than for a gasoline vehicle because diesel fuel has a 14.5% higher carbon content per gallon than gasoline. Accordingly, a 30 mpg diesel vehicle would have a CO_2 equivalent value of 339 grams per mile. Emissions for vehicles other than gasoline and diesel are also calculated using appropriate emissions factors.

Example Comparison of Fuel Economy Metrics

The multiple ways of measuring fuel economy and GHG emissions can understandably lead to confusion. As an illustration to help the reader understand the various fuel economy values that can be associated with an individual vehicle, Table 1.2 shows three different fuel economy metrics for the model year 2018 Toyota Prius Eco. The 2-cycle city and highway fuel economy values are direct fuel economy measurements from the 2-cycle tests and are harmonically averaged with a 55% city / 45% highway weighting to generate a combined value. The 2-cycle laboratory tested city fuel economy of the Prius Eco is 84 mpg, the highway fuel economy is 78 mpg, and the combined 2-cycle value is 81 mpg.

Using the 5-cycle methodology, the Toyota Prius Eco has a vehicle fuel economy label value of 56 mpg city and 58 mpg highway. On the vehicle label, these values are harmonically averaged using a 55% city / 45% highway weighting to determine a combined value of 53 mpg. The estimated real-world fuel economy for the Prius Eco, which is the set of values used in calculations for this report, has the same city and highway fuel economy as the

label, but the 43% city and 57% highway weighting leads to a combined value of 55 mpg, which is one mpg less than the values found on the label.

Table C.1 Fuel Economy Metrics for the Model Year 2018 Toyota Prius Eco

Fuel Economy Metric	Purpose	City/Highway Weighting	Test Basis	Fuel Economy Value (MPG)		
				Combined City/Hwy	City	Hwy
2-cycle Test (unadjusted)	Basis for manufacturer compliance with standards	55% / 45%	2-cycle	81	84	78
Label	Consumer information to compare individual vehicles	55% / 45%	5-cycle	56	58	53
Estimated Real-World	Best estimate of real-world performance	43% / 57%	5-cycle	55	58	53

Greenhouse Gases other than CO_2

In addition to tailpipe CO_2 emissions, vehicles may create greenhouse gas emissions in several other ways. The combustion process can result in emissions of N_2O, and CH_4, and leaks in vehicle air conditioning systems can release refrigerants, which are also greenhouse gases, into the environment. N_2O, CH_4, and air conditioning greenhouse gases are discussed as part of the GHG regulatory program in Section 5. Estimated real-world CO_2 emissions in Sections 1–4 only account for tailpipe CO_2 emissions.

The life cycle of the vehicle (including manufacturing and vehicle disposal) and the life cycle of the fuels (including production and distribution) can also create significant greenhouse gases. Life cycle implications of vehicles and fuels can vary widely based on the vehicle technology and fuel and are outside the scope of this report. However, there is academic research, both published and ongoing, in this area for interested readers.

D. Historical Changes in the Database and Methodology

Over the course of this report's publication, there have been some instances where relevant methodologies and definitions have been updated. Since the goal of this report is to provide the most accurate data and science available, updates are generally propagated back to through the historical database. The current version of this report supersedes all previous reports.

Changes in Estimated Real-world Fuel Economy and CO_2

The estimated real-world fuel economy values in this report are closely related to the label fuel economy values. Over the course of this report, there have been three updates to the fuel economy label methodology (for model years 1985, 2008, and 2017), and these updates were propagated through the Trends database. However, there are some important differences in how the label methodology updates have been applied in this report. This section discusses how these methodologies have been applied, partially or in full, to the appropriate model years based on the authors' technical judgement. The changes are intended to provide accurate real-world values for vehicles at the time they were produced to better reflect available technologies, changes in driving patterns, and composition of the fleet. These changes are also applicable to real-world CO_2 values, which are converted from fuel economy values using emissions factors.

Model year 1975–1985: Universal Multipliers

The first change to the label methodology occurred when EPA recognized that changing technology and driving habits led to real-world fuel economy results that over time were diverging from the fuel economy values measured using the 2-cycle tests. To address this issue, EPA introduced an alternative calculation methodology in 1985 that applied a multiplication factor to the 2-cycle test data of 0.9 for city and 0.78 for highway. The estimated real-world fuel economy values from model year 1975–1985 in this report were calculated using the same multiplication factors that were required for the model year 1985 label update. The authors believe that these correction factors were appropriate for new vehicles from model year 1975 through 1985. The combined fuel economy and CO_2 values are based on a 55% city/45% highway weighting factor, consistent with the CAFE and label fuel economy calculations.

Model year 1986–2010: The 2006 5-cycle methodology and 43% City/57% Highway Weighting

In 2006, EPA established a major change to the fuel economy label calculations by introducing the 5-cycle methodology.[25] In addition to the city and highway tests required for 2-cycle fuel economy, the 5-cycle methodology introduces tests for high speeds (US06), air-conditioning (SC03), and a cold temperature test. It also indirectly accounts for a number of other factors that are not reflected in EPA laboratory test data (e.g., changing fuel composition, wind, road conditions) through the use of a 9.5% universal downward adjustment factor. The change from the universal adjustment factors to the 2006 5-cycle method lowered estimated real-world fuel economy values, particularly for high fuel economy vehicles. In the 2006 rulemaking, EPA projected an overall average fleetwide adjustment of 11% lower for city fuel economy and 8% lower for highway fuel economy.

For model year 1986–2004, the authors implemented the 2006 5-cycle methodology by assuming the changes in technology and driver behavior that led to lower real-world fuel economy occurred in a gradual, linear manner over 20 years. We did not attempt to perform a year-by-year analysis to determine the extent to which the many relevant factors (including higher highway speed limits, more aggressive driving, increasing vehicle horsepower-to-weight ratios, suburbanization, congestion, greater use of air conditioning, gasoline composition, etc.) that have affected real-world fuel economy since 1985 have changed over time.

Under the 5-cycle methodology, manufacturers could either: 1) perform all five tests on each vehicle (the "full 5-cycle" method), 2) use an alternative analytical "derived 5-cycle" method based on 2-cycle testing if certain conditions were met, or 3) voluntarily use lower fuel economy label estimates than those resulting from the full 5-cycle or derived 5-cycle. If manufacturers are required to perform all five tests, the results are weighted according to composite 5-cycle equations.[26] To use the derived 5-cycle method, manufacturers are required to evaluate whether fuel economy estimates using the full 5-cycle tests are comparable to results using the derived 5-cycle method. In recent years, the derived 5-cycle approach has been used to generate approximately 85% of all vehicle label fuel economy values.

For vehicles that were eligible to use the 2006 derived 5-cycle methodology, the following equations were used to convert 2-cycle city and highway fuel economy values to label

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[25] See 71 Federal Register 77872, December 27, 2006.
[26] See 71 Federal Register 77883-77886, December 27, 2006.

economy values. These equations were based on the relationship between 2-cycle and 5-cycle fuel economy data for the industry as a whole.

$$\textbf{Label CITY} = \cfrac{1}{\left(0.003259 + \cfrac{1.1805}{\text{2CYCLE CITY}}\right)}$$

$$\textbf{Label HWY} = \cfrac{1}{\left(0.001376 + \cfrac{1.3466}{\text{2CYCLE HWY}}\right)}$$

Over the same timeframe, EPA phased in a change in the city and highway weightings used to determine a single combined fuel economy or CO_2 value. EPA's analysis of real-world driving activity underlying the 5-cycle fuel economy methodology assumed a "speed cutpoint" of 45 miles per hour to differentiate between (and "bin" the amount of) city and highway driving.[27] Based on this speed cutpoint, the correct weighting for correlating the new city and highway fuel economy values with real-world driving activity data from on-road vehicle studies, on a miles driven basis, is 43% city and 57% highway; this updated weighting is necessary to maintain the integrity of fleetwide fuel economy performance based on Trends data. The 55% city / 45% highway weighting is still used for both Fuel Economy and Environment Labels and the CAFE and GHG emissions compliance programs. The authors used the same gradual, linear approach to phase in the change in city and highway weightings along with the phase-in of the 2006 5-cycle methodology.

From model year 2005 to model year 2010, the 2006 5-cycle methodology and the 43% city / 57% highway weightings were used to determine the real-world fuel economy values for this report. This required using the derived 5-cycle equations and the 43% city / 57% highway weightings to recalculate real-world fuel economy values for model year 2005 to 2007, because the 2006 5-cycle methodology was not required until 2008. Model year 2008 to model year 2010 real-world fuel economy values were the same as the label fuel economy values, except for the city and highway weightings.

Model year 2011–2018: Implementing the model year 2017 derived 5-cycle updates

In 2015, EPA released a minor update to the derived 5-cycle equations that modified the coefficients used to calculate derived 5-cycle fuel economy from 2-cycle test data.[28] This

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[27] See 71 Federal Register 77904, December 27, 2006.
[28] See https://www.epa.gov/fueleconomy/basic-information-fuel-economy-labeling and http://iaspub.epa.gov/otaqpub/display_file.jsp?docid=35113&flag=1

update was required under existing regulations and applies to fuel economy label calculations for all model year 2017 and later vehicles. The following equations are used to convert 2-cycle test data values for city and highway to label fuel economy values:

$$\textbf{Label CITY} = \cfrac{1}{\left(0.004091 + \cfrac{1.1601}{\text{2CYCLE CITY}}\right)}$$

$$\textbf{Label HWY} = \cfrac{1}{\left(0.003191 + \cfrac{1.2945}{\text{2CYCLE HWY}}\right)}$$

The updated 5-cycle calculations introduced for model year 2017 labels were based on test data from model year 2011 to model year 2016 vehicles. Therefore, the authors chose to apply the updated 5-cycle methodology to all model years from 2011 to 2018. This required recalculating the real-world fuel economy of vehicles from model year 2011 to 2016 using the new derived 5-cycle equations. Vehicles that conducted full 5-cycle testing or voluntarily lowered fuel economy values were unchanged. The 43% city/ 57% highway weightings were maintained for all vehicles in model years 2011 to 2018. The changes due to the 5-cycle update were relatively small (0.1 to 0.2 mpg overall) and did not noticeably alter the general data trends, therefore the authors determined that a phase-in period was not required for this update.

Figure D.1 below summarizes the impact of the changes in real-world data methodology relative to the 2-cycle test data, which has had a consistent methodology since 1975 (See Appendix C for more information). Over time, the estimated real-world fuel economy of new vehicles has continued to slowly diverge from 2-cycle test data, due largely to changing technology, driving patterns, and vehicle design.

Figure D.1. Estimated Real-World versus 2-Cycle Fuel Economy since Model Year 1975

Phase I 1975–1985	Phase II 1986–2006	Phase III 2007–2010	Phase IV 2011–2018
Universal adjustment factors	2006 5-cycle is phase-in	5-cycle	Updated 5-cycle
		43/57% weighting	43/57% weighting
55/45% weighting	43/57% weighting phase-in		

Legend:
— 2-cycle method unchanged since 1975
— Estimated Real-World Phases I - IV

Ratio of Real-World Estimated to 2-cycle: 76.9%

Ratio of Real-World Estimated to 2-cycle: 85.2%

Other Database Changes

Addition of Medium-Duty Passenger Vehicles

Beginning in 2011 medium-duty passenger vehicles (MDPVs), those SUVs and passenger vans (but not pickup trucks) with gross vehicle weight ratings between 8,500 and 10,000 pounds, are included in the light-duty truck category. This coincided with new regulations by NHTSA to treat these vehicles as light-duty, rather than heavy-duty, vehicles beginning in model year 2011. This represents a minor change to the database, since the number of MDPVs is much smaller than it once was (e.g., only 6,500 MDPVs were sold in model year 2012). It should be noted that this is one change to the database that has not been propagated back through the historic database, as we do not have MDPV data prior to model year 2011. Accordingly, this represents a small inflection point for the database for the overall car and truck fleet in model year 2011; the inclusion of MDPVs decreased average real-world fuel economy by 0.01 mpg and increased average real-world CO_2

emissions by 0.3 g/mi, compared to the fleet without MDPVs. The impacts on the truck fleet only were about twice as high, but still very small in absolute terms. Pickup trucks above 8,500 pounds are not included in this report.

Addition of Alternative Fuel Vehicles

Data from alternative fuel vehicles are integrated into the overall database, beginning with MY 2011 data. These vehicles include electric vehicles, plug-in hybrid vehicles, fuel cell vehicles, and compressed natural gas vehicles. CO_2 emissions from alternative fuel vehicles represent tailpipe emissions, and fuel economy for these vehicles is reported as mpge (miles per gallon of gasoline equivalent), or the miles an alternative fuel vehicle can travel on an amount of energy equivalent to that in a gallon of gasoline. Sales data prior to MY 2011 are included in some cases based on available industry reports (e.g., Ward's Automotive data).

Changes in Vehicle Classification Definitions

The car-truck classifications in this report follow the current regulatory definitions used by EPA and NHTSA for compliance with GHG emissions and CAFE standards (see definitions for passenger automobiles (cars) and non-passenger automobiles (trucks) in 49 CFR 523). These current definitions differ from those used in the 2010 and older versions of the *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends* report, and reflect a decision by NHTSA to reclassify many small, 2-wheel drive sport utility vehicles (SUVs) from the truck category to the car category, beginning with model year 2011. When this re-classification was initiated in the 2011 report, the absolute truck share decreased by approximately 10%.

The current car-truck definitions have been propagated back throughout the entire historical Trends database to maintain the integrity of long-term trends of car and truck production share. Since the authors did not have all of the requisite technical information on which to make retroactive car-truck classifications, we used engineering judgment to classify past models.

This report previously presented data on more vehicle types, but recent vehicle design has led to far less distinction between vehicle types and reporting on more disaggregated vehicle types was no longer useful.

Manufacturer Definitions

When a manufacturer grouping changes under the GHG and CAFE programs, the current manufacturer definitions are generally applied to all prior model years. This maintains consistent manufacturer and make definitions over time, which enables better identification of long-term trends. However, some of the compliance data maintain the previous manufacturer definitions where necessary to preserve the integrity of compliance data as they were accrued.

Differences in Production Data Between CAFE and GHG Regulations

The data used to discuss real-world trends in Sections 1 through 4 of this report are based on production volumes reported under CAFE prior to model year 2017, not the GHG standards. The production volume levels automakers provide in their final CAFE reports may differ slightly from their final GHG reports (typically less than 0.1%) because of different reporting requirements. The EPA regulations require emission compliance in the 50 states, the District of Columbia, Puerto Rico, the Virgin Islands, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands, whereas the CAFE program requires data from the 50 states, the District of Columbia, and Puerto Rico only. All compliance data detailed in Section 5, for all years, are based on production volumes reported under the GHG standards. Starting with model year 2017 and forward, the real-world data are also based on production volumes reported under EPA' s GHG standards. As described above, the difference in production volumes is very small and does not impact the long-term trends or analysis.

E. Electric Vehicle and Plug-In Hybrid Metrics

Electric Vehicles (EVs) and Plug-in Hybrid Vehicles (PHEVs) have continued to gain market share. While overall market penetration of these vehicles is still low, their production share is projected to reach more than 3.3% in model year 2019. This section addresses some of the technical metrics used both to quantify EV and PHEV operation and to integrate data from these vehicles with gasoline and diesel vehicle data.

EVs operate using only energy stored in a battery from external charging. PHEVs blend EV technology with more familiar powertrain technology from petroleum-fueled vehicles. Current PHEVs feature both an electric drive system designed to be charged from an electricity source external to the vehicle (like an EV) and a gasoline internal combustion engine. There are generally three ways that a PHEV can operate:

1. Charge-depleting electric-only mode – In electric-only mode the vehicle operates like an EV, using only energy stored in the battery to propel the vehicle.

2. Charge-depleting blended mode – In blended mode the vehicle uses both energy stored in the battery and energy from the gasoline tank to propel the vehicle. Depending on the vehicle design and driving conditions, blended operation can include substantial all-electric driving.

3. Charge-sustaining mode – In charge-sustaining mode, the PHEV has exhausted the external energy from the electric grid that is stored in the battery and relies on the gasoline internal combustion engine. In charge-sustaining mode, the vehicle will operate much like a traditional hybrid.

The presence of both electric drive and an internal combustion engine results in a complex system that can be used in many different combinations, and manufacturers are choosing to operate PHEV systems in different ways. This complicates direct comparisons among PHEV models.

This section discusses EV and PHEV metrics for several example model year 2019 vehicles. For consistency and clarity for the reader, the data for specific vehicles discussed in this section reflect values from the EPA/DOT Fuel Economy and Environment Labels, which use a 55% city/ 45% highway weighting for combined fuel economy and CO_2 values. When data for these vehicles are integrated into the data for the rest of the report, the real-world highway and city values are combined using a 43% city/ 57% highway weighting. Additionally, some PHEV calculations are also adjusted, as explained at the end of this section.

Table E.1 shows the label driving range for several EVs and PHEVs when operating only on electricity, as well as the total electricity plus gasoline range for PHEVs. The average range of new EVs is increasing, as shown in Section 4, and many EVs are approaching the range of an average gasoline vehicle. [29] PHEVs generally have a much smaller all electric range, however the combined electric and gasoline range for PHEVs often exceeds gasoline-only vehicles. Several PHEVs now exceed 500 miles of total range.

Table E.1. Model Year 2019 Example EV and PHEV Powertrain and Range

Manufacturer	Model	Fuel or Powertrain	Electric Range (miles)	Total Range (miles)	Utility Factor
GM	Bolt	EV	238	238	-
Nissan	Leaf 62kWh	EV	226	226	-
Tesla	Model 3 LR	EV	325	325	-
FCA	Pacifica	PHEV	32	520	0.61
GM	Volt	PHEV	53	420	0.76
Honda	Clarity	PHEV	48	340	0.73
Toyota	Prius Prime	PHEV	25	640	0.53
Volvo	XC90	PHEV	17	490	0.40

Determining the electric range of PHEVs is complicated if the vehicle can operate in blended modes. For PHEVs like the Chevrolet Volt, which cannot operate in blended mode, the electric range represents the estimated range operating in electric only mode. However, for PHEVs that operate in a blended mode, the electric range represents the estimated range of the vehicle operating in either electric only *or* blended mode, due to the design of the vehicle. For example, the Volvo XC90 uses electricity stored in its battery and a small amount of gasoline to achieve an alternative fuel range of 17 miles. Some PHEVs did not use any gasoline to achieve their electric range value on EPA test cycles; however, certain driving conditions (e.g., more aggressive accelerations, higher speeds, and air conditioning or heater operation) would likely cause these vehicles to operate in a blended mode instead of an all-electric mode.

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[29] In addition to growing EV range, the number of public electric vehicle charging stations is growing rapidly. For more information, see the U.S. Department of Energy's Alternative Fuels Data Center at https://www.afdc.energy.gov/.

Table E.1 also introduces the concept of a utility factor. The utility factor is directly related to the electric range for PHEVs, and is a projection, on average, of the percentage of miles that will be driven using electricity (in electric-only and blended modes) by an average driver. The model year 2019 Volt, for example, has a utility factor of 0.76, i.e., it is expected that, on average, the Volt will operate 76% of the time on electricity and 24% of the time on gasoline. Utility factor calculations are based on an SAE methodology that EPA has adopted for regulatory compliance (SAE 2010).

Table E.2 shows five energy-related metrics for model year 2018 example EVs and PHEVs that are included on the EPA/NHTSA Fuel Economy and Environment labels. Comparing the energy or fuel efficiency performance from alternative fuel vehicles raises complex issues of how to compare different fuels. Consumers and OEMs are familiar and comfortable with evaluating gasoline and diesel vehicle fuel economy in terms of miles per gallon, and it is the primary efficiency metric in this report. To enable this comparison for alternative fuel vehicles, the overall energy efficiency of vehicles operating on electricity, hydrogen, and CNG are evaluated in terms of miles per gallon of gasoline equivalent (an energy metric described in more detail below).

Table E.2. Model Year 2019 Example EV and PHEV Fuel Economy Label Metrics

Manufacturer	Model	Fuel or Power -train	Charge Depleting			Charge Sustaining Fuel Economy (mpg)	Overall Fuel Economy (mpge)
			Electricity (kW-hrs/ 100 miles)	Gasoline (gallons/ 100 miles)	Fuel Economy (mpge)		
GM	Bolt	EV	28	-	119	N/A	119
Nissan	Leaf 62kWh	EV	31	-	108	N/A	108
Tesla	Model 3 LR	EV	26	-	130	N/A	130
FCA	Pacifica	PHEV	41	0.0	82	30	48
GM	Volt	PHEV	31	0.0	106	42	79
Honda	Clarity	PHEV	31	0.0	110	42	76
Toyota	Prius Prime	PHEV	25	0.0	133	54	78
Volvo	XC90	PHEV	55	0.1	58	25	33

The fourth column in Table E.2 gives electricity consumption rates for EVs and PHEVs during charge depleting operation in units of kilowatt-hours per 100 miles (kW-hrs/100 miles). As shown on the vehicle label, the electricity consumption rate is based on the amount of electricity required from an electric outlet to charge the vehicle and includes

wall-to-vehicle charging losses. The values for all of the EVs and PHEVs reflect the electricity consumption rate required to operate the vehicle in either electric-only or blended mode operation. PHEVs that are capable of operating in a blended mode may also consume some gasoline in addition to electricity. Any additional gasoline used is shown in the fifth column. For example, the Volvo XC90 PHEV consumes 55 kW-hrs and 0.1 gallons of gasoline per 100 miles during this combination of electric-only and blended modes.

The sixth column converts the electricity consumption data in the fourth column and the gasoline consumption data in the fifth column into a combined miles per gallon of gasoline-equivalent (mpge) metric. The mpge metric is a measure of the miles the vehicle can travel on an amount of energy that is equal to the amount of energy stored in a gallon of gasoline. For a vehicle operating on electricity, mpge is calculated as 33.705 kW-hrs/gallon divided by the vehicle electricity consumption in kW-hrs/mile. For example, for the Leaf, 33.705 kW-hrs/gallon divided by 0.31 kW-hrs/mile (equivalent to 31 kW-hrs/100 miles) is 108 mpge.[30] Because the Volvo XC90 consumes both electricity and gasoline over the alternative fuel range of 17 miles, the charge depleting fuel economy of 58 mpge includes both the electricity and gasoline consumption, at a rate of 55 kW-hrs/100 miles of electricity and 0.1 gal/100 miles of gasoline.

The seventh column gives label fuel economy values for vehicles operating on gasoline only, which is relevant here only for the PHEVs operating in charge sustaining mode. For PHEVs, the EPA/NHTSA label shows both electricity consumption in kW-hrs/100 miles and mpge, when the vehicle operates exclusively on electricity or in a blended mode, and gasoline fuel economy in mpg, when the vehicle operates exclusively on gasoline.

The final column gives the overall mpge values reflecting the overall energy efficiency of the vehicle for all of the fuels on which the vehicle can operate, and provide a common metric to compare vehicles that operate on different fuels. In addition to the energy metrics in the previous columns, the one key additional parameter necessary to calculate a combined electricity/gasoline mpge value for a PHEV is the utility factor that was introduced in Table E.1. For EVs the overall fuel economy in the last column is equal to the charge depleting fuel economy, as EVs can only operate in a charge depleting mode.

Table E.3 gives vehicle tailpipe CO_2 emissions values that are included on the EPA/DOT Fuel Economy and Environment labels (and reflected in the label's Greenhouse Gas Rating). These label values reflect EPA's best estimate of the CO_2 tailpipe emissions that these

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[30] The actual calculations were done with unrounded numbers. Using the rounded numbers provided here may result in a slightly different number due to rounding error.

vehicles will produce, on average, in real-world city and highway operation. EVs, of course, have no tailpipe emissions. For the PHEVs, the label CO_2 emissions values utilize the same utility factors discussed above to weight the CO_2 emissions on electric and gasoline operation.

Table E-3 Model Year 2019 Example EV and PHEV Label Tailpipe CO_2 Emissions Metrics

Manufacturer	Model	Fuel or Powertrain	Tailpipe CO_2 (g/mile)
GM	Bolt	EV	0
Nissan	Leaf 62 kWh	EV	0
Tesla	Model 3 LR	EV	0
FCA	Pacifica	PHEV	119
GM	Volt	PHEV	51
Honda	Clarity	PHEV	57
Toyota	Prius Prime	PHEV	78
Volvo	XC90	PHEV	216

Table E.4 accounts for the "upstream" CO_2 emissions associated with the production and distribution of electricity used in EVs and PHEVs. Gasoline and diesel fuels also have CO_2 emissions associated with their production and distribution, but these upstream emissions are not reflected in the tailpipe CO_2 emissions values discussed elsewhere in this report. Combining vehicle tailpipe and fuel production/distribution sources, gasoline vehicles emit about 80 percent of total CO_2 emissions at the vehicle tailpipe with the remaining 20 percent of total CO_2 emissions associated with upstream fuel production and distribution. Diesel fuel has a similar approximate relationship between tailpipe and upstream CO_2 emissions. On the other hand, vehicles powered by grid electricity emit no CO_2 (or other emissions) at the vehicle tailpipe; therefore, all CO_2 emissions associated with an EV are due to fuel production and distribution. Depending on how the electricity is produced, these fuels can have very high fuel production/distribution CO_2 emissions (for example, if coal is used with no CO_2 emissions control) or very low CO_2 emissions (for example, if renewable processes with minimal fossil energy inputs are used).

An additional complicating factor in Table E.4 is that electricity production in the United States varies significantly from region to region and has been changing over time. Hydroelectric plants provide a large percentage of electricity in the Northwest, while coal-fired power plants produce the majority of electricity in the Midwest. Natural gas, wind, and solar have increased their electricity market share in many regions of the country. Nuclear

power plants make up most of the balance of U.S. electricity production. In order to bracket the possible GHG emissions impact, Table E.4 provides ranges with the low end of the range corresponding to the California power plant GHG emissions factor, the middle of the range represented by the national average power plant GHG emissions factor, and the upper end of the range corresponding to the power plant GHG emissions factor for part of the Midwest (Illinois and Missouri).

Table E-4 Model Year 2019 Example EV and PHEV Upstream CO_2 Emission Metrics (g/mi)

Manufacturer	Model	Fuel or Powertrain	Tailpipe + Total Upstream CO_2			Tailpipe + Net Upstream CO_2		
			Low	Avg	High	Low	Avg	High
GM	Bolt	EV	72	134	230	16	77	173
Nissan	Leaf 62 kWh	EV	79	147	251	20	87	192
Tesla	Model 3 LR	EV	66	122	210	1	57	144
FCA	Pacifica	PHEV	213	267	351	126	180	265
GM	Volt	PHEV	124	176	256	66	117	187
Honda	Clarity	PHEV	129	178	255	69	119	195
Toyota	Prius Prime	PHEV	131	160	205	80	109	154
Volvo	XC90	PHEV	327	375	450	238	286	361
Average Sedan/Wagon			**366**	**366**	**366**	**293**	**293**	**293**

Based on data from EPA's eGRID power plant database,[31] and accounting for additional greenhouse gas emissions impacts for feedstock processing upstream of the power plant,[32] EPA estimates that the electricity CO_2 emission factors for various regions of the country vary from 256 g CO_2/kW-hr in California to 811 g CO_2/kW-hr in the Midwest, with a national average of 473 g CO_2/kW-hr. Emission rates for small regions in upstate New York and Alaska have lower electricity upstream CO_2 emission rates than California. However, California is a good surrogate for the "low" end of the range because California is a leading market for current EVs and PHEVs. Initial sales of electric vehicles have been largely, though not exclusively, focused in regions of the country with power plant CO_2 emissions factors lower than the national average, such as California, New York, and other coastal areas. Accordingly, in terms of CO_2 emissions, EPA believes that the current "sales-weighted

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[31] Abt Associates 2020. The emissions & generation resource integrated database technical support document for eGRID 2018, prepared for the U.S. Environmental Protection Agency, January 2020.
[32] Argonne National Laboratory 2019. GREET_1_2019 Model. greet.es.anl.gov.

average" vehicle operating on electricity in the near term will likely fall somewhere between the low end of this range and the national average.[33]

The fourth through sixth columns in Table E-4 provide the range of tailpipe plus *total* upstream CO_2 emissions for EVs and PHEVs based on regional electricity emission rates. For comparison, the average model year 2019 car is also included in the last row of Table . The methodology used to calculate the range of tailpipe plus total upstream CO_2 emissions for EVs is shown in the following example for the model year 2019 Nissan Leaf (62 kWh battery):

- Start with the label (5-cycle values weighted 55% city/45% highway) vehicle electricity consumption in kW-hr/mile, which for the Leaf is 31 kW-hr/100 miles, or 0.31 kW-hr/mile

- Determine the regional powerplant emission rate, regional losses during electricity distribution, and the additional regional emissions due to fuel production upstream of the powerplant (for California, these numbers are 225 g/kW-hr, 4.8%, and 8.3%, respectively).

- Determine the regional upstream emission factor (for California 225 g/kW-hr / (1–0.048) * (1+0.083) = 256 g CO_2/kW-hr)[34]

- Multiply by the range of Low (California = 256g CO_2/kW-hr), Average (National Average = 473 g CO_2/kW-hr), and High (Midwest = 811 g CO_2/kW-hr) electricity upstream CO_2 emission rates, which yields a range for the Leaf of 79-251 grams CO_2/mile.

The tailpipe plus total upstream CO_2 emissions values for PHEVs include the upstream CO_2 emissions due to electricity operation and both the tailpipe and upstream CO_2 emissions due to gasoline operation, using the utility factor discussed above to weight the values for electricity and gasoline operation. The tailpipe plus total upstream CO_2 emissions values for the average car are the average real-world model year 2018 car tailpipe CO_2 emissions multiplied by 1.25 to account for upstream emissions due to gasoline production.

The values in columns four through six are tailpipe plus *total* upstream CO_2 emissions. As mentioned, all of the gasoline and diesel vehicle CO_2 emissions data in the rest of this report refer only to tailpipe emissions and do not reflect the upstream emissions

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[33] To estimate the upstream greenhouse gas emissions associated with operating an EV or PHEV in a specific geographical area, use the emissions calculator at www.fueleconomy.gov/feg/Find.do?action=bt2.
[34] The actual calculations were done with unrounded numbers. Using the rounded numbers provided here may result in a slightly different number due to rounding error.

associated with gasoline or diesel production and distribution. Accordingly, in order to equitably compare the overall relative impact of EVs and PHEVs with tailpipe emissions of petroleum-fueled vehicles, EPA uses the metric "tailpipe plus *net* upstream emissions" for EVs and PHEVs (note that this same approach has been adopted for EV and PHEV regulatory compliance with the 2012–2025 light-duty vehicle GHG emissions standards for sales of EVs and PHEVs in model year 2012–2016 and model year 2022–2025 that exceed sales thresholds). The net upstream emissions for an EV is equal to the total upstream emissions for the EV minus the upstream emissions that would be expected from a comparably sized gasoline vehicle; size is a good first-order measure for utility, and footprint is the size-based metric used for standards compliance. The net upstream emissions for PHEVs are equal to the net upstream emissions of the PHEV due to electricity consumption in electric or blended mode multiplied by the utility factor. The net upstream emissions for a gasoline vehicle are zero.

For each EV or PHEV, the upstream emissions for a comparable gasoline vehicle are determined by first using the footprint-based compliance curves to determine the CO_2 compliance target for a vehicle with the same footprint. Since upstream emissions account for approximately 20% of total CO_2 emissions for gasoline vehicles, the upstream emissions for the comparable gasoline vehicle are equal to one-fourth of the tailpipe-only compliance target.

The final three columns of Table E-4 give the tailpipe plus net upstream CO_2 values for EVs and PHEVs using the same Low, Average, and High electricity upstream CO_2 emissions rates discussed above. These values bracket the possible real-world net CO_2 emissions that would be associated with consumer use of these vehicles. For the Leaf, these values are simply the values in columns four through six minus the upstream GHG emissions of a comparably sized gasoline vehicle. Based on the model year 2019 CO_2 footprint curve, the 5-cycle tailpipe GHG emissions for a Leaf-sized gasoline vehicle meeting its compliance target would be close to 238 grams/mi, with upstream emissions of one-fourth of this value, or 60 g/mi. The net upstream emision for a Leaf (with the 62 kWh battery) are determined by subtracting this value, 60 g/mi, from the total (tailpipe + total upstream). The result is a range for the tailpipe plus net upstream value of 20–192 g/mile as shown in Table E-4, with a more likely sales-weighted value in the 20–87 g/mi range.

For PHEVs, the tailpipe plus net upstream emissions values use the utility factor values discussed above to weight the individual values for electric operation and gasoline operation.

Alternative Metrics for EVs and PHEVs

Determining metrics for EVs and PHEVs that are meaningful and accurate is challenging. In particular, vehicles capable of using dual fuels, such as PHEVs, can have complicated modes of operation that make it difficult to determine meaningful metrics. Here we've discussed several metrics that are used on the EPA/DOT Fuel Economy and Environment Labels and in a regulatory context, namely mpge, tailpipe CO_2 emissions, and net upstream GHG emissions. There are, however, other ways that alternative fuel vehicle operation can be quantified.

Other energy metric options that could be considered include: (1) mpge plus net fuel life cycle energy, which would also reflect differences in upstream energy consumption in producing the alternative fuel relative to gasoline-from-oil; and (2) miles per gallon of gasoline, which would only count gasoline use and not other forms of energy. Compared to mpge, using the mpge plus net fuel life-cycle energy metric would generally result in lower fuel economy values, and using the miles per gallon of gasoline metric would yield higher fuel economy values.

Additional Note on PHEV Calculations

Calculating fuel economy and CO_2 emission values for PHEVs is a complicated process, as discussed in this section. The examples given for individual vehicles were based on calculations behind the EPA/DOT Fuel Economy and Environment Labels. In addition to the approach used for the labels, there are multiple methods for determining utility factors depending on the intended use of the value. The standardized utility factor calculations are defined in the Society of Automobile Engineers (SAE) document SAE J2841.

The utility factors that are used for fleetwide calculations are somewhat different than those used to create label values. For label values, multi-day individual utility factors (MDIUF) are used to incorporate "a driver's day to day variation into the utility calculation." For fleetwide calculations, fleet utility factors (FUF) are applied to "calculate the expected fuel and electric consumption of an entire fleet of vehicles." Since the Trends report is generally a fleetwide analysis, the FUF utility factors were applied, instead of the MDIUF utility factors, when the data were integrated with the rest of the fleet data. Additionally, since Trends uses a 43% city / 57% highway weighting for combining real-world fuel economy and CO_2 data, the FUF utility factors created for Trends were based on that weighting, not on 55% city / 45% highway weighting used on the fuel economy label.

F. Authors and Acknowledgments

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Table 2.1

**Production, Estimated Real-World CO2, and Fuel Economy
for Model Year 1975–2019**

Model Year	Production (000)	Real-World CO$_2$ (g/mi)	Real-World FE (mpg)
1975	10,224	681	13.1
1976	12,334	625	14.2
1977	14,123	590	15.1
1978	14,448	562	15.8
1979	13,882	560	15.9
1980	11,306	466	19.2
1981	10,554	436	20.5
1982	9,732	425	21.1
1983	10,302	426	21.0
1984	14,020	424	21.0
1985	14,460	417	21.3
1985	14,460	417	21.3
1985	14,460	417	21.3
1986	15,365	407	21.8
1987	14,865	405	22.0
1988	15,295	407	21.9
1989	14,453	415	21.4
1990	12,615	420	21.2
1991	12,573	418	21.3
1992	12,172	427	20.8
1993	13,211	426	20.9
1994	14,125	436	20.4
1995	15,145	434	20.5
1996	13,144	435	20.4
1997	14,458	441	20.2
1998	14,456	442	20.1
1999	15,215	451	19.7
1999	15,215	451	19.7
1999	15,215	451	19.7
2000	16,571	450	19.8
2001	15,605	453	19.6
2002	16,115	457	19.5
2003	15,773	454	19.6
2004	15,709	461	19.3
2005	15,892	447	19.9
2006	15,104	442	20.1
2007	15,276	431	20.6
2008	13,898	424	21.0
2009	9,316	397	22.4
2010	11,116	394	22.6
2011	12,018	399	22.3
2012	13,449	377	23.6
2013	15,198	368	24.2
2014	15,512	369	24.1
2015	16,739	360	24.6
2016	16,278	359	24.7
2017	17,016	357	24.9
2018	16,259	353	25.1
2019 (prelim)	-	346	25.5

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Table 2.2
Manufactures and Vehicles with the Highest Fuel Economy, by Year

Model Year	Manufacturer with Highest Fuel Economy* (mpg)	Manufacturer with Lowest Fuel Economy (mpg)	Overall Vehicle with Highest Fuel Economy**			Gasoline (Non-hybrid) Vehicle with Highest Fuel Economy (mpg)	
			Vehicle	Real-World FE (mpg)	Engine Type	Gasoline Vehicle	Real-World FE (mpg)
1975	Honda	Ford	Honda Civic	28.3	Gas	Honda Civic	28.3
1976	Honda	Ford	Honda Civic	30.5	Gas	Honda Civic	30.5
1977	Honda	FCA	Honda Civic	37.6	Gas	Honda Civic	37.6
1978	Mazda	Ford	VW Rabbit	37.5	Diesel	Nissan B-210	34.3
1979	Honda	Ford	VW Rabbit	39.1	Diesel	Nissan 210	33.6
1980	VW	Ford	VW Rabbit	40.3	Diesel	Nissan 210	36.1
1981	VW	Ford	VW Rabbit	40.9	Diesel	Toyota Starlet	37.9
1982	Honda	Ford	VW Rabbit	42.7	Diesel	Nissan Sentra	41.0
1983	Honda	Ford	Nissan Sentra	45.3	Diesel	Honda Civic	42.4
1984	Honda	Ford	Honda Civic	48.0	Gas	Honda Civic	48.0
1985	Honda	Mercedes	GM Sprint	49.6	Gas	GM Sprint	49.6
1986	Hyundai	Mercedes	GM Sprint	56.8	Gas	GM Sprint	56.8
1987	Hyundai	Mercedes	GM Sprint	54.8	Gas	GM Sprint	54.8
1988	Hyundai	Mercedes	GM Metro	54.4	Gas	GM Metro	54.4
1989	Hyundai	Mercedes	Honda Civic	50.6	Gas	Honda Civic	50.6
1990	Hyundai	Mercedes	GM Metro	53.4	Gas	GM Metro	53.4
1991	Hyundai	Mercedes	GM Metro	53.0	Gas	GM Metro	53.0
1992	Hyundai	Mercedes	GM Metro	52.6	Gas	GM Metro	52.6
1993	Honda	Mercedes	GM Metro	52.2	Gas	GM Metro	52.2
1994	Kia	FCA	GM Metro	52.2	Gas	GM Metro	52.2
1995	Honda	FCA	Honda Civic	47.3	Gas	Honda Civic	47.3
1996	Hyundai	FCA	Suzuki Swift	43.3	Gas	Suzuki Swift	43.3
1997	Hyundai	FCA	GM Metro	42.8	Gas	GM Metro	42.8
1998	Honda	FCA	GM Metro	42.0	Gas	GM Metro	42.0
1999	Hyundai	FCA	VW Jetta	41.0	Diesel	GM Metro	39.3
2000	Hyundai	FCA	Honda Insight	57.4	Hybrid	GM Metro	39.4
2001	Hyundai	FCA	Honda Insight	56.3	Hybrid	Honda Civic	37.3
2002	Honda	FCA	Honda Insight	55.6	Hybrid	Honda Civic	35.9
2003	Honda	Ford	Honda Insight	55.0	Hybrid	Honda Civic	35.5
2004	Honda	Ford	Honda Insight	53.5	Hybrid	Honda Civic	35.3
2005	Honda	Ford	Honda Insight	53.3	Hybrid	Honda Civic	35.1
2006	Mazda	Ford	Honda Insight	53.0	Hybrid	Toyota Corolla	32.3
2007	Toyota	Mercedes	Toyota Prius	46.2	Hybrid	Toyota Yaris	32.6
2008	Hyundai	Mercedes	Toyota Prius	46.2	Hybrid	Smart Fortwo	37.1
2009	Toyota	FCA	Toyota Prius	46.2	Hybrid	Smart Fortwo	37.1
2010	Hyundai	Mercedes	Honda FCX	60.2	FCV	Smart Fortwo	36.8
2011	Hyundai	Mercedes	BMW Active E	100.6	EV	Smart Fortwo	35.7
2012	Hyundai	FCA	Nissan i-MiEV	109.0	EV	Toyota iQ	36.8
2013	Hyundai	FCA	Toyota IQ	117.0	EV	Toyota iQ	36.8
2014	Mazda	FCA	BMW i3	121.3	EV	Mitsubishi Mirage	39.5
2015	Mazda	FCA	BMW i3	121.3	EV	Mitsubishi Mirage	39.5
2016	Mazda	FCA	BMW i3	121.3	EV	Mazda 2	37.1
2017	Honda	FCA	Hyundai Ioniq	132.6	EV	Mitsubishi Mirage	41.5
2018	Tesla	FCA	Hyundai Ioniq	132.6	EV	Mitsubishi Mirage	41.5
2019 (prelim)	Tesla	FCA	Hyundai Ioniq	132.6	EV	Mitsubishi Mirage	40.1

* Manufacturers below the 150,000 threshold for "large" manufacturers are excluded in years they did not meet the threshold.

** Vehicles are shown based on estimated real-world fuel economy as calculated for this report. These values will differ from values found on the fuel economy labels at the time of sale. For more information on fuel economy metrics see Appendix C.

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Table 2.3
Manufacturer Estimated Real-World Fuel Economy and CO_2 Emissions for Model Year 2017 - 2019

Manufacturer	MY 2017 Final		MY 2018 Final				MY 2019 Preliminary	
	Real-World FE (mpg)	Real-World CO_2 (g/mi)	Real-World FE (mpg)	FE Change from MY 2017 (mpg)	Real-World CO_2 (g/mi)	CO_2 Change from MY 2017 (g/mi)	Real-World FE (mpg)	Real-World CO_2 (g/mi)
BMW	25.8	342	26.0	0.2	339	-3	26.0	340
FCA	21.1	420	21.7	0.6	409	-11	22.3	398
Ford	22.9	388	22.4	-0.4	397	8	22.8	390
GM	22.8	388	23.0	0.2	386	-2	22.8	389
Honda	29.4	302	30.0	0.6	296	-6	28.8	308
Hyundai	28.6	311	28.6	0.0	311	0	27.3	324
Kia	27.1	327	27.8	0.6	319	-8	27.6	321
Mazda	29.0	306	28.7	-0.4	310	4	27.8	322
Mercedes	23.0	385	23.5	0.5	377	-8	24.4	363
Nissan	26.9	330	27.1	0.2	327	-3	26.9	328
Subaru	28.5	312	28.7	0.2	310	-2	28.1	317
Tesla	98.2	0	113.7	15.5	0	0	117.7	0
Toyota	25.3	351	25.5	0.2	348	-3	26.1	341
VW	26.4	336	24.6	-1.8	361	25	26.4	336
All Manufacturers	24.9	357	25.1	0.2	353	-4	25.5	346

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Table 3.1
Vehicle Attributes by Model Year

Model Year	Real-World CO_2 (g/mi)	Real-World FE (mpg)	Weight (lbs)	HP	0 to 60 (s)	Footprint (sq ft)	Car Production	Truck Production
1975	681	13.1	4,060	137	-	-	80.7%	19.3%
1976	625	14.2	4,079	135	-	-	78.9%	21.1%
1977	590	15.1	3,982	136	-	-	80.1%	19.9%
1978	562	15.8	3,715	129	13.6	-	77.5%	22.5%
1979	560	15.9	3,655	124	14.6	-	77.9%	22.1%
1980	466	19.2	3,228	104	15.6	-	83.5%	16.5%
1981	436	20.5	3,202	102	15.6	-	82.8%	17.2%
1982	425	21.1	3,202	103	16.6	-	80.5%	19.5%
1983	426	21.0	3,257	107	14.9	-	78.0%	22.0%
1984	424	21.0	3,262	109	14.7	-	76.5%	23.5%
1985	417	21.3	3,271	114	14.1	-	75.2%	24.8%
1986	407	21.8	3,238	114	13.4	-	72.1%	27.9%
1987	405	22.0	3,221	118	13.4	-	72.8%	27.2%
1988	407	21.9	3,283	123	13.3	-	70.9%	29.1%
1989	415	21.4	3,351	129	12.5	-	70.1%	29.9%
1990	420	21.2	3,426	135	11.5	-	70.4%	29.6%
1991	418	21.3	3,410	138	11.4	-	69.6%	30.4%
1992	427	20.8	3,512	145	11.0	-	68.6%	31.4%
1993	426	20.9	3,519	147	10.3	-	67.6%	32.4%
1994	436	20.4	3,603	152	10.1	-	61.9%	38.1%
1995	434	20.5	3,613	158	10.1	-	63.5%	36.5%
1996	435	20.4	3,659	164	10.4	-	62.2%	37.8%
1997	441	20.2	3,727	169	10.2	-	60.1%	39.9%
1998	442	20.1	3,744	171	10.4	-	58.3%	41.7%
1999	451	19.7	3,835	179	10.3	-	58.3%	41.7%
2000	450	19.8	3,821	181	9.8	-	58.8%	41.2%
2001	453	19.6	3,879	187	9.5	-	58.6%	41.4%
2002	457	19.5	3,951	195	9.4	-	55.2%	44.8%
2003	454	19.6	3,999	199	9.3	-	53.9%	46.1%
2004	461	19.3	4,111	211	9.1	-	52.0%	48.0%
2005	447	19.9	4,059	209	9.0	-	55.6%	44.4%
2006	442	20.1	4,067	213	8.9	-	57.9%	42.1%
2007	431	20.6	4,093	217	8.9	-	58.9%	41.1%
2008	424	21.0	4,085	219	8.9	48.9	59.3%	40.7%
2009	397	22.4	3,914	208	8.8	47.9	67.0%	33.0%
2010	394	22.6	4,001	214	8.8	48.5	62.8%	37.2%
2011	399	22.3	4,126	230	8.5	49.5	57.8%	42.2%
2012	377	23.6	3,979	222	8.5	48.8	64.4%	35.6%
2013	368	24.2	4,003	226	8.4	49.1	64.1%	35.9%
2014	369	24.1	4,060	230	8.3	49.7	59.3%	40.7%
2015	360	24.6	4,035	229	8.3	49.4	57.4%	42.6%
2016	359	24.7	4,035	230	8.3	49.5	55.3%	44.7%
2017	357	24.9	4,093	234	8.2	49.8	52.5%	47.5%
2018	353	25.1	4,137	241	8.0	50.4	47.9%	52.1%
2019 (prelim)	346	25.5	4,110	244	7.8	50.2	49.8%	50.2%

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Table 3.2

Estimated Real-World Fuel Economy and CO_2 by Vehicle Type

Model Year	Sedan/Wagon			Car SUV			Truck SUV			Minivan/Van			Pickup		
	Prod Share	Real-World CO_2 (g/mi)	Real-World FE (mpg)	Prod Share	Real-World CO_2 (g/mi)	Real-World FE (mpg)	Prod Share	Real-World CO_2 (g/mi)	Real-World FE (mpg)	Prod Share	Real-World CO_2 (g/mi)	Real-World FE (mpg)	Prod Share	Real-World CO_2 (g/mi)	Real-World FE (mpg)
1975	80.6%	660	13.5	0.1%	799	11.1	1.7%	806	11.0	4.5%	800	11.1	13.1%	746	11.9
1976	78.8%	598	14.9	0.1%	840	10.6	1.9%	755	11.8	4.1%	754	11.8	15.1%	714	12.4
1977	80.0%	570	15.6	0.1%	731	12.2	1.9%	692	12.8	3.6%	710	12.5	14.3%	656	13.6
1978	77.3%	525	16.9	0.1%	768	11.6	2.5%	723	12.3	4.3%	736	12.1	15.7%	668	13.3
1979	77.8%	517	17.2	0.1%	623	14.3	2.8%	844	10.5	3.5%	774	11.5	15.9%	674	13.2
1980	83.5%	446	20.0	0.0%	610	14.6	1.6%	676	13.2	2.1%	629	14.1	12.7%	541	16.5
1981	82.7%	418	21.4	0.0%	605	14.7	1.3%	621	14.3	2.3%	599	14.8	13.6%	500	17.9
1982	80.3%	402	22.2	0.1%	450	19.8	1.5%	616	14.7	3.2%	605	14.7	14.8%	486	18.5
1983	77.7%	403	22.1	0.3%	430	20.7	2.5%	568	15.8	3.7%	593	15.1	15.8%	473	18.9
1984	76.1%	397	22.4	0.4%	461	19.3	4.1%	551	16.2	4.8%	552	16.1	14.6%	488	18.3
1985	74.6%	387	23.0	0.6%	443	20.1	4.5%	538	16.5	5.9%	537	16.5	14.4%	489	18.2
1986	71.7%	375	23.7	0.4%	470	18.9	4.6%	523	17.0	6.8%	509	17.5	16.5%	471	18.9
1987	72.2%	373	23.8	0.6%	458	19.4	5.2%	515	17.3	7.5%	503	17.7	14.4%	467	19.0
1988	70.2%	368	24.1	0.7%	462	19.2	5.6%	522	17.0	7.4%	497	17.9	16.1%	490	18.1
1989	69.3%	375	23.7	0.7%	465	19.1	5.7%	537	16.6	8.8%	499	17.8	15.4%	499	17.8
1990	69.8%	381	23.3	0.5%	472	18.8	5.1%	541	16.4	10.0%	498	17.8	14.5%	511	17.4
1991	67.8%	379	23.4	1.8%	488	18.2	6.9%	531	16.7	8.2%	496	17.9	15.3%	489	18.2
1992	66.6%	385	23.1	2.0%	498	17.8	6.2%	548	16.2	10.0%	496	17.9	15.1%	508	17.5
1993	64.0%	379	23.5	3.6%	522	17.0	6.3%	546	16.3	10.9%	488	18.2	15.2%	505	17.6
1994	59.6%	382	23.3	2.3%	493	18.0	9.1%	555	16.0	10.0%	498	17.8	18.9%	510	17.4
1995	62.0%	379	23.4	1.5%	499	17.8	10.5%	555	16.0	11.0%	492	18.1	15.0%	526	16.9
1996	60.0%	381	23.3	2.2%	482	18.4	12.2%	548	16.2	10.7%	485	18.3	14.9%	518	17.1
1997	57.6%	380	23.4	2.5%	462	19.2	14.5%	551	16.1	8.8%	489	18.2	16.7%	528	16.8
1998	55.1%	380	23.4	3.1%	487	18.2	14.7%	550	16.2	10.3%	475	18.7	16.7%	523	17.0
1999	55.1%	386	23.0	3.2%	480	18.5	15.4%	553	16.1	9.6%	486	18.3	16.7%	546	16.3
2000	55.1%	388	22.9	3.7%	497	17.9	15.2%	555	16.0	10.2%	478	18.6	15.8%	534	16.7
2001	53.9%	386	23.0	4.8%	472	18.8	17.3%	541	16.4	7.9%	493	18.0	16.1%	557	16.0
2002	51.5%	385	23.1	3.7%	460	19.3	22.3%	545	16.3	7.7%	475	18.7	14.8%	564	15.8
2003	50.2%	382	23.3	3.6%	446	19.9	22.6%	541	16.4	7.8%	468	19.0	15.7%	553	16.1
2004	48.0%	384	23.1	4.1%	445	20.0	25.9%	539	16.5	6.1%	464	19.2	15.9%	565	15.7
2005	50.5%	379	23.5	5.1%	440	20.2	20.6%	531	16.7	9.3%	460	19.3	14.5%	561	15.8
2006	52.9%	382	23.3	5.0%	434	20.5	19.9%	518	17.2	7.7%	455	19.5	14.5%	551	16.1
2007	52.9%	369	24.1	6.0%	431	20.6	21.7%	503	17.7	5.5%	456	19.5	13.8%	550	16.2
2008	52.7%	366	24.3	6.6%	419	21.2	22.1%	489	18.2	5.7%	448	19.8	12.9%	539	16.5
2009	60.5%	351	25.3	6.5%	403	22.0	18.4%	461	19.3	4.0%	443	20.1	10.6%	526	16.9
2010	54.5%	340	26.2	8.2%	386	23.0	20.7%	452	19.7	5.0%	442	20.1	11.5%	527	16.9
2011	47.8%	344	25.8	10.0%	378	23.5	25.5%	449	19.8	4.3%	424	20.9	12.3%	516	17.2
2012	55.0%	322	27.6	9.4%	381	23.3	20.6%	445	20.0	4.9%	418	21.3	10.1%	516	17.2
2013	54.1%	313	28.4	10.0%	365	24.3	21.8%	427	20.8	3.8%	422	21.1	10.4%	509	17.5
2014	49.2%	313	28.4	10.1%	364	24.4	23.9%	412	21.6	4.3%	418	21.3	12.4%	493	18.0
2015	47.2%	306	29.0	10.2%	353	25.1	28.1%	406	21.9	3.9%	408	21.8	10.7%	474	18.8
2016	43.8%	303	29.2	11.5%	338	26.2	29.1%	400	22.2	3.9%	410	21.7	11.7%	471	18.9
2017	41.0%	293	30.2	11.5%	339	26.2	31.8%	398	22.3	3.6%	399	22.2	12.1%	470	18.9
2018	36.7%	286	30.8	11.3%	324	27.3	35.1%	384	23.1	3.1%	389	22.8	13.9%	466	19.1
2019 (prelim)	38.5%	283	30.8	11.3%	327	27.0	33.1%	375	23.7	3.4%	387	22.8	13.8%	459	19.4

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Table 3.3:
Model Year 2018 Vehicle Attributes by Manufacturer

Manufacturer	Real-World CO_2 (g/mi)	Real-World FE (mpg)	Weight (lbs)	HP	0 to 60 (s)	Footprint (ft²)
BMW	339	26.0	4,190	268	6.8	48.3
FCA	409	21.7	4,465	278	7.5	52.0
Ford	397	22.4	4,476	284	7.5	55.3
GM	386	23.0	4,543	269	7.9	54.4
Honda	296	30.0	3,595	202	8.1	47.4
Hyundai	311	28.6	3,470	175	8.9	46.6
Kia	319	27.8	3,521	182	8.7	46.9
Mazda	310	28.7	3,769	187	8.9	46.5
Mercedes	377	23.5	4,430	285	7.0	49.6
Nissan	327	27.1	3,806	201	8.9	47.8
Subaru	310	28.7	3,680	177	9.4	45.0
Tesla	0	113.7	4,523	393	4.7	50.4
Toyota	348	25.5	4,083	220	8.4	48.8
VW	361	24.6	4,168	251	7.6	48.4
Other	351	25.3	4,201	240	8.4	48.1
All Manufacturers	**353**	**25.1**	**4,137**	**241**	**8.0**	**50.4**

Table 3.4

Model Year 2018 Estimated Real-World Fuel Economy and CO_2 by Manufacturer and Vehicle Type

Manufacturer	Sedan/Wagon			Car SUV			Truck SUV			Minivan/Van			Pickup		
	Prod Share	Real-World CO_2 (g/mi)	Real-World FE (mpg)	Prod Share	Real-World CO_2 (g/mi)	Real-World FE (mpg)	Prod Share	Real-World CO_2 (g/mi)	Real-World FE (mpg)	Prod Share	Real-World CO_2 (g/mi)	Real-World FE (mpg)	Prod Share	Real-World CO_2 (g/mi)	Real-World FE (mpg)
BMW	73.2%	322	27.3	-	-	-	26.8%	387	22.9	-	-	-	-	-	-
FCA	12.1%	397	22.4	7.5%	339	26.2	55.3%	411	21.6	13.0%	386	22.9	12.1%	483	18.5
Ford	22.0%	313	28.4	12.2%	349	25.5	29.8%	416	21.4	1.7%	418	21.3	34.2%	450	19.8
GM	22.5%	297	29.6	14.7%	308	28.9	30.6%	405	22.0	-	-	-	32.2%	466	19.1
Honda	53.7%	263	33.6	9.7%	294	30.2	28.4%	332	26.7	6.9%	382	23.3	1.3%	408	21.8
Hyundai	59.6%	279	31.8	37.3%	353	25.2	3.1%	431	20.6	-	-	-	-	-	-
Kia	67.9%	290	30.6	11.2%	346	25.7	17.4%	397	22.4	3.5%	426	20.9	-	-	-
Mazda	45.4%	288	30.9	18.5%	311	28.6	36.1%	337	26.3	-	-	-	-	-	-
Mercedes	46.0%	343	25.9	11.5%	339	26.2	40.2%	426	20.8	2.2%	413	21.5	-	-	-
Nissan	57.0%	294	30.1	10.5%	295	30.1	23.8%	369	24.1	1.0%	353	25.2	7.7%	481	18.5
Subaru	22.3%	312	28.4	-	-	-	77.7%	309	28.8	-	-	-	-	-	-
Tesla	87.8%	0	118.0	8.7%	0	89.9	3.5%	0	90.3	-	-	-	-	-	-
Toyota	39.9%	267	33.2	11.0%	336	26.4	32.9%	389	22.8	2.8%	397	22.4	13.4%	489	18.2
VW	44.8%	326	27.2	0.4%	380	23.4	54.9%	389	22.8	-	-	-	-	-	-
Other	20.6%	294	30.2	8.9%	330	27.0	68.6%	372	23.9	1.9%	338	26.3	-	-	-
All Manufacturers	**36.7%**	**286**	**30.8**	**11.3%**	**324**	**27.3**	**35.1%**	**384**	**23.1**	**3.1%**	**389**	**22.8**	**13.9%**	**466**	**19.1**

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Table 3.5
Footprint by Manufacturer for Model Year 2017 - 2019 (ft^2)

Manufacturer	Final MY 2017			Final MY 2018			Preliminary MY 2019		
	Car	Truck	All	Car	Truck	All	Car	Truck	All
BMW	46.7	50.6	47.9	47.3	51.1	48.3	46.6	51.5	48.6
FCA	47.4	54.1	52.8	48.9	52.8	52.0	48.1	54.3	52.7
Ford	46.9	57.3	52.5	46.6	59.9	55.3	47.6	58.9	55.1
GM	46.6	58.9	53.5	46.4	59.2	54.4	46.2	57.5	53.6
Honda	45.9	49.7	47.1	46.3	49.4	47.4	46.9	50.3	48.0
Hyundai	46.3	49.2	46.5	46.5	49.2	46.6	46.6	49.2	47.0
Kia	46.1	50.0	47.2	46.2	49.5	46.9	47.1	49.1	47.5
Mazda	45.5	47.2	46.0	45.6	47.9	46.5	45.3	47.7	46.3
Mercedes	48.5	52.0	50.0	48.3	51.3	49.6	47.9	51.3	48.8
Nissan	46.1	51.9	48.0	46.0	51.7	47.8	46.2	52.4	48.3
Subaru	45.1	45.0	45.0	44.9	45.0	45.0	44.8	45.8	45.6
Tesla	53.8	-	53.8	50.3	54.8	50.4	50.0	54.8	50.1
Toyota	45.6	52.6	49.0	46.1	51.6	48.8	46.0	51.6	48.8
VW	45.0	50.2	46.3	45.9	50.5	48.4	45.5	51.1	47.6
Other	44.6	49.3	47.3	45.0	49.4	48.1	46.0	48.9	48.1
All Manufacturers	**46.2**	**53.8**	**49.8**	**46.5**	**53.9**	**50.4**	**46.7**	**53.6**	**50.2**

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Table 4.1
Production Share by Engine Technologies

Model Year	Powertrain				Fuel Delivery Method						Avg. No. of Cylinders	CID	HP	Multi-Valve	VVT	CD	Turbo	Stop/Start
	Gasoline	Gasoline Hybrid	Diesel	Other	Carb	GDI	Port	TBI	EV	FCV								
1975	99.8%		0.2%		95.7%	-	4.1%	0.0%	-	-	6.8	293	137	-	-	-	-	-
1976	99.8%		0.2%		97.3%	-	2.5%	0.0%	-	-	6.9	294	135	-	-	-	-	-
1977	99.6%		0.4%		96.2%	-	3.4%	0.0%	-	-	6.9	287	136	-	-	-	-	-
1978	99.1%		0.9%		95.2%	-	3.9%	0.0%	-	-	6.7	266	129	-	-	-	-	-
1979	98.0%		2.0%		94.2%	-	3.7%	0.1%	-	-	6.5	252	124	-	-	-	-	-
1980	95.7%		4.3%		89.7%	-	5.2%	0.8%	-	-	5.6	198	104	-	-	-	-	-
1981	94.1%		5.9%		86.7%	-	5.1%	2.4%	-	-	5.5	193	102	-	-	-	-	-
1982	94.4%		5.6%		80.6%	-	5.8%	8.0%	-	-	5.4	188	103	-	-	-	-	-
1983	97.3%		2.7%		75.2%	-	7.3%	14.8%	-	-	5.5	193	107	-	-	-	-	-
1984	98.2%		1.8%		67.6%	-	11.9%	18.7%	-	-	5.5	190	109	-	-	-	-	-
1985	99.1%		0.9%		56.1%	-	18.2%	24.8%	-	-	5.5	189	114	-	-	-	-	-
1986	99.6%		0.4%		41.4%	-	32.5%	25.7%	-	-	5.3	180	114	3.4%	-	-	-	-
1987	99.7%		0.3%		28.4%	-	39.9%	31.4%	-	-	5.2	175	118	10.6%	-	-	-	-
1988	99.9%		0.1%		15.0%	-	50.6%	34.3%	-	-	5.3	180	123	14.0%	-	-	-	-
1989	99.9%		0.1%		8.7%	-	57.3%	33.9%	-	-	5.4	185	129	16.9%	-	-	-	-
1990	99.9%		0.1%		2.1%	-	70.8%	27.0%	-	-	5.4	185	135	23.1%	-	-	-	-
1991	99.9%		0.1%		0.6%	-	70.6%	28.7%	-	-	5.3	184	138	23.1%	-	-	-	-
1992	99.9%		0.1%		0.5%	-	81.6%	17.8%	-	-	5.5	191	145	23.3%	-	-	-	-
1993	100.0%		-		0.3%	-	85.0%	14.6%	-	-	5.5	191	147	23.5%	-	-	-	-
1994	100.0%		0.0%		0.1%	-	87.7%	12.1%	-	-	5.6	197	152	26.7%	-	-	-	-
1995	100.0%		0.0%		-	-	91.6%	8.4%	-	-	5.6	196	158	35.6%	-	-	-	-
1996	99.9%		0.1%		-	-	99.3%	0.7%	-	-	5.6	197	164	39.3%	-	-	0.2%	-
1997	99.9%		0.1%		-	-	99.5%	0.5%	-	-	5.7	199	169	39.6%	-	-	0.4%	-
1998	99.9%		0.1%		-	-	99.8%	0.1%	-	-	5.6	199	171	40.9%	-	-	0.8%	-
1999	99.9%		0.1%		-	-	99.9%	0.1%	-	-	5.8	203	179	43.4%	-	-	1.4%	-
2000	99.8%	0.0%	0.1%		-	-	99.8%	0.0%	-	-	5.7	200	181	44.8%	15.0%	-	1.3%	-
2001	99.7%	0.1%	0.1%		-	-	99.9%	-	-	-	5.8	201	187	49.0%	19.6%	-	2.0%	-
2002	99.6%	0.2%	0.2%		-	-	99.8%	-	-	-	5.8	203	195	53.3%	25.3%	-	2.2%	-
2003	99.5%	0.3%	0.2%		-	-	99.8%	-	-	-	5.8	204	199	55.5%	30.6%	-	1.2%	-
2004	99.4%	0.5%	0.1%		-	-	99.9%	-	-	-	5.9	212	211	62.3%	38.5%	-	2.3%	-
2005	98.6%	1.1%	0.3%		-	-	99.7%	-	-	-	5.8	205	209	65.6%	45.8%	0.8%	1.7%	-
2006	98.1%	1.5%	0.4%		-	-	99.6%	-	-	-	5.7	204	213	71.7%	55.4%	3.6%	2.1%	-
2007	97.7%	2.2%	0.1%		-	-	99.8%	-	-	-	5.6	203	217	71.7%	57.3%	7.3%	2.5%	-
2008	97.4%	2.5%	0.1%		-	2.3%	97.6%	-	-	-	5.6	199	219	76.4%	58.2%	6.7%	3.0%	-
2009	97.2%	2.3%	0.5%		-	4.2%	95.2%	-	-	-	5.2	183	208	83.8%	71.5%	7.3%	3.3%	-
2010	95.5%	3.8%	0.7%	0.0%	-	8.3%	91.0%	-	-	0.0%	5.3	188	214	85.5%	83.8%	6.4%	3.3%	-
2011	97.0%	2.2%	0.8%	0.1%	-	15.4%	83.8%	-	0.1%	0.0%	5.4	192	230	86.4%	93.1%	9.5%	6.8%	-
2012	95.5%	3.1%	0.9%	0.4%	-	22.5%	76.5%	-	0.1%	0.0%	5.1	181	222	91.8%	96.6%	8.1%	8.4%	0.6%
2013	94.8%	3.6%	0.9%	0.7%	-	30.5%	68.3%	-	0.3%	-	5.1	176	226	92.8%	97.4%	7.7%	13.9%	2.3%
2014	95.7%	2.6%	1.0%	0.7%	-	37.4%	61.3%	-	0.3%	0.0%	5.1	180	230	89.2%	97.6%	10.6%	14.8%	5.1%
2015	95.9%	2.4%	0.9%	0.7%	-	41.9%	56.7%	-	0.5%	0.0%	5.0	177	229	91.2%	97.2%	10.5%	15.7%	7.1%
2016	96.9%	1.8%	0.5%	0.8%	-	48.0%	51.0%	-	0.5%	0.0%	5.0	174	230	92.3%	98.0%	10.4%	19.9%	9.6%
2017	96.1%	2.3%	0.3%	1.4%	-	49.7%	49.4%	-	0.6%	0.0%	5.0	174	234	92.0%	98.1%	11.9%	23.4%	17.8%
2018	95.1%	2.3%	0.4%	2.2%	-	50.2%	48.0%	-	1.4%	0.0%	5.0	172	241	91.0%	96.4%	12.5%	30.0%	29.8%
2019 (prelim)	91.0%	5.0%	0.7%	3.3%	-	54.2%	42.4%	-	2.6%	0.0%	5.0	169	244	90.5%	95.3%	13.1%	33.6%	36.3%

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Table 4.2
Production Share by Transmission Technologies

Model Year	Manual	Automatic with Lockup	Automatic without Lockup	CVT (Hybrid)	CVT (Non-Hybrid)	Other	4 Gears or Fewer	5 Gears	6 Gears	7 Gears	8 Gears	9+ Gears	CVT (Hybrid)	CVT (Non-Hybrid)	Avg. No. of Gears
1975	23.0%	0.2%	76.8%	-	-	-	99.0%	1.0%	-	-	-	-	-	-	-
1976	20.9%	-	79.1%	-	-	-	100.0%	-	-	-	-	-	-	-	-
1977	19.8%	-	80.2%	-	-	-	100.0%	-	-	-	-	-	-	-	-
1978	22.7%	5.5%	71.9%	-	-	-	92.7%	7.3%	-	-	-	-	-	-	-
1979	24.2%	7.3%	68.1%	-	-	0.4%	93.8%	6.2%	-	-	-	-	-	-	3.3
1980	34.6%	18.1%	46.8%	-	-	0.5%	87.9%	12.1%	-	-	-	-	-	-	3.5
1981	33.6%	33.0%	32.9%	-	-	0.5%	85.6%	14.4%	-	-	-	-	-	-	3.5
1982	32.4%	47.8%	19.4%	-	-	0.4%	84.4%	15.6%	-	-	-	-	-	-	3.6
1983	30.5%	52.1%	17.0%	-	-	0.4%	80.9%	19.1%	-	-	-	-	-	-	3.7
1984	28.4%	52.8%	18.8%	-	-	0.0%	81.3%	18.7%	-	-	-	-	-	-	3.7
1985	26.5%	54.5%	19.1%	-	-	-	80.7%	19.3%	-	-	-	-	-	-	3.8
1986	29.8%	53.5%	16.7%	-	-	-	76.8%	23.2%	-	-	-	-	-	-	3.8
1987	29.1%	55.4%	15.5%	-	-	0.0%	76.2%	23.8%	-	-	-	-	-	-	3.9
1988	27.6%	62.2%	10.2%	-	-	-	76.8%	23.2%	-	-	-	-	-	-	3.9
1989	24.6%	65.5%	9.9%	-	0.1%	0.0%	78.5%	21.4%	0.0%	-	-	-	-	0.1%	3.9
1990	22.2%	71.2%	6.5%	-	0.0%	0.0%	79.9%	20.0%	0.1%	-	-	-	-	0.0%	4.0
1991	23.9%	71.6%	4.5%	-	0.0%	-	77.3%	22.6%	0.0%	-	-	-	-	0.0%	4.0
1992	20.7%	74.8%	4.5%	-	0.0%	-	80.8%	19.2%	0.1%	-	-	-	-	0.0%	4.0
1993	19.8%	76.5%	3.7%	-	0.0%	-	80.9%	19.0%	0.1%	-	-	-	-	0.0%	4.0
1994	19.5%	77.6%	3.0%	-	-	-	80.8%	19.0%	0.2%	-	-	-	-	-	4.1
1995	17.9%	80.7%	1.4%	-	-	-	82.0%	17.7%	0.2%	-	-	-	-	-	4.1
1996	15.2%	83.5%	1.3%	-	0.0%	0.0%	84.7%	15.1%	0.2%	-	-	-	-	0.0%	4.1
1997	14.0%	85.5%	0.5%	-	0.0%	-	82.4%	17.3%	0.2%	-	-	-	-	0.0%	4.1
1998	12.8%	86.7%	0.5%	-	0.0%	-	82.1%	17.7%	0.2%	-	-	-	-	0.0%	4.1
1999	10.1%	89.4%	0.5%	-	0.0%	-	84.4%	15.3%	0.3%	-	-	-	-	0.0%	4.1
2000	9.7%	89.5%	0.7%	-	0.0%	-	83.7%	15.8%	0.5%	-	-	-	-	0.0%	4.1
2001	9.0%	90.3%	0.6%	0.1%	0.0%	-	80.7%	18.5%	0.7%	-	-	-	0.1%	0.0%	4.2
2002	8.2%	91.4%	0.3%	0.1%	0.1%	-	77.1%	21.6%	1.1%	-	-	-	0.1%	0.1%	4.2
2003	8.0%	90.8%	0.1%	0.3%	0.8%	-	69.2%	28.1%	1.7%	-	-	-	0.3%	0.8%	4.3
2004	6.8%	91.8%	0.3%	0.4%	0.7%	-	63.9%	31.8%	3.0%	0.2%	-	-	0.4%	0.7%	4.4
2005	6.2%	91.5%	0.1%	1.0%	1.3%	-	56.0%	37.3%	4.1%	0.2%	-	-	1.0%	1.3%	4.5
2006	6.5%	90.6%	0.0%	1.5%	1.4%	-	47.7%	39.2%	8.8%	1.4%	-	-	1.5%	1.4%	4.6
2007	5.6%	87.1%	0.0%	2.1%	5.1%	-	40.5%	36.1%	14.4%	1.5%	0.2%	-	2.1%	5.1%	4.8
2008	5.2%	86.8%	0.2%	2.4%	5.5%	-	38.8%	31.9%	19.4%	1.8%	0.2%	-	2.4%	5.5%	4.8
2009	4.8%	85.6%	0.2%	2.1%	7.3%	-	31.2%	32.2%	24.5%	2.5%	0.1%	-	2.1%	7.3%	5.0
2010	3.8%	84.1%	1.2%	3.8%	7.2%	-	24.6%	23.5%	38.1%	2.7%	0.2%	-	3.8%	7.2%	5.2
2011	3.2%	86.5%	0.3%	2.0%	8.0%	-	14.2%	18.7%	52.3%	3.1%	1.7%	-	2.0%	8.0%	5.5
2012	3.6%	83.4%	1.1%	2.7%	9.2%	-	8.1%	18.2%	56.3%	2.8%	2.6%	-	2.7%	9.2%	5.5
2013	3.5%	80.4%	1.4%	2.9%	11.8%	-	5.4%	12.8%	60.1%	2.8%	4.1%	-	2.9%	11.8%	5.6
2014	2.8%	76.7%	1.6%	2.3%	16.6%	-	2.2%	7.8%	58.4%	3.3%	8.4%	1.1%	2.3%	16.6%	5.9
2015	2.6%	72.3%	1.4%	2.2%	21.5%	-	1.5%	4.5%	54.2%	3.1%	9.5%	3.5%	2.2%	21.5%	5.9
2016	2.2%	72.3%	2.6%	1.7%	21.2%	-	1.1%	3.0%	54.9%	2.9%	11.2%	4.1%	1.7%	21.2%	6.0
2017	2.1%	71.5%	2.6%	1.9%	21.8%	-	1.0%	2.4%	49.0%	3.4%	14.6%	5.9%	1.9%	21.8%	6.1
2018	1.6%	72.8%	3.2%	1.7%	20.6%	-	1.9%	2.0%	37.6%	3.7%	19.0%	13.5%	1.7%	20.6%	6.4
2019 (prelim)	2.0%	70.5%	3.5%	2.2%	21.9%	-	2.9%	1.2%	23.7%	2.9%	25.5%	19.6%	2.2%	21.9%	6.6

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Table 4.3
Production Share by Drive Technology

Model Year	Car			Truck			All		
	Front Wheel Drive	Rear Wheel Drive	Four Wheel Drive	Front Wheel Drive	Rear Wheel Drive	Four Wheel Drive	Front Wheel Drive	Rear Wheel Drive	Four Wheel Drive
1975	6.5%	93.5%	-	-	82.8%	17.2%	5.3%	91.4%	3.3%
1976	5.8%	94.2%	-	-	77.0%	23.0%	4.6%	90.6%	4.8%
1977	6.8%	93.2%	-	-	76.2%	23.8%	5.5%	89.8%	4.7%
1978	9.6%	90.4%	-	-	70.9%	29.1%	7.4%	86.0%	6.6%
1979	11.9%	87.8%	0.3%	-	81.9%	18.1%	9.2%	86.5%	4.3%
1980	29.7%	69.4%	0.9%	1.4%	73.6%	25.0%	25.0%	70.1%	4.9%
1981	37.0%	62.2%	0.7%	1.9%	78.0%	20.1%	31.0%	65.0%	4.0%
1982	45.6%	53.6%	0.8%	1.7%	78.1%	20.2%	37.0%	58.4%	4.6%
1983	47.1%	49.9%	3.1%	1.4%	72.5%	26.1%	37.0%	54.8%	8.1%
1984	53.5%	45.5%	1.0%	5.0%	63.5%	31.5%	42.1%	49.8%	8.2%
1985	61.1%	36.8%	2.1%	7.3%	61.4%	31.3%	47.8%	42.9%	9.3%
1986	70.7%	28.2%	1.0%	5.9%	63.4%	30.7%	52.6%	38.0%	9.3%
1987	76.4%	22.6%	1.1%	7.6%	60.2%	32.2%	57.7%	32.8%	9.6%
1988	80.9%	18.3%	0.8%	9.2%	56.7%	34.1%	60.0%	29.5%	10.5%
1989	81.6%	17.4%	1.0%	10.1%	57.1%	32.8%	60.2%	29.3%	10.5%
1990	84.0%	15.0%	1.0%	15.8%	52.4%	31.8%	63.8%	26.1%	10.1%
1991	81.1%	17.5%	1.3%	10.3%	52.3%	37.3%	59.6%	28.1%	12.3%
1992	78.4%	20.5%	1.1%	14.5%	52.1%	33.4%	58.4%	30.4%	11.2%
1993	80.6%	18.3%	1.1%	16.8%	50.6%	32.7%	59.9%	28.8%	11.3%
1994	81.3%	18.3%	0.4%	13.8%	47.0%	39.2%	55.6%	29.2%	15.2%
1995	80.1%	18.8%	1.1%	18.4%	39.3%	42.3%	57.6%	26.3%	16.2%
1996	83.7%	14.8%	1.4%	20.9%	39.8%	39.2%	60.0%	24.3%	15.7%
1997	83.8%	14.5%	1.7%	14.2%	40.6%	45.2%	56.1%	24.9%	19.0%
1998	82.9%	15.0%	2.1%	19.3%	35.5%	45.1%	56.4%	23.5%	20.1%
1999	83.2%	14.7%	2.1%	17.5%	34.4%	48.1%	55.8%	22.9%	21.3%
2000	80.4%	17.7%	2.0%	20.0%	33.8%	46.3%	55.5%	24.3%	20.2%
2001	80.3%	16.7%	3.0%	16.3%	34.8%	48.8%	53.8%	24.2%	22.0%
2002	82.9%	13.5%	3.6%	15.4%	33.1%	51.6%	52.7%	22.3%	25.0%
2003	80.9%	15.9%	3.2%	15.4%	34.1%	50.4%	50.7%	24.3%	25.0%
2004	80.2%	14.5%	5.3%	12.5%	31.0%	56.5%	47.7%	22.4%	29.8%
2005	79.2%	14.2%	6.6%	20.1%	27.7%	52.2%	53.0%	20.2%	26.8%
2006	75.9%	18.0%	6.0%	18.9%	28.0%	53.1%	51.9%	22.3%	25.8%
2007	81.0%	13.4%	5.6%	16.1%	28.4%	55.5%	54.3%	19.6%	26.1%
2008	78.8%	14.1%	7.1%	18.4%	24.8%	56.8%	54.2%	18.5%	27.3%
2009	83.5%	10.2%	6.3%	21.0%	20.5%	58.5%	62.9%	13.6%	23.5%
2010	82.5%	11.2%	6.3%	20.9%	18.0%	61.0%	59.6%	13.7%	26.7%
2011	80.1%	11.3%	8.6%	17.7%	17.3%	65.0%	53.8%	13.8%	32.4%
2012	83.8%	8.8%	7.5%	20.9%	14.8%	64.3%	61.4%	10.9%	27.7%
2013	83.0%	9.3%	7.7%	18.1%	14.5%	67.5%	59.7%	11.1%	29.1%
2014	81.3%	10.6%	8.2%	17.5%	14.2%	68.3%	55.3%	12.1%	32.6%
2015	80.4%	9.7%	9.9%	16.0%	12.6%	71.4%	52.9%	10.9%	36.1%
2016	79.8%	9.1%	11.0%	15.9%	12.2%	72.0%	51.2%	10.5%	38.3%
2017	79.8%	8.3%	11.9%	16.1%	11.0%	72.8%	49.6%	9.6%	40.8%
2018	76.6%	9.4%	14.0%	13.4%	10.9%	75.6%	43.7%	10.2%	46.1%
2019 (prelim)	74.0%	11.6%	14.5%	14.5%	11.1%	74.3%	44.1%	11.3%	44.5%

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Figure 5.3
Changes in "2-Cycle" Tailpipe CO_2 Emissions, Model Year 2012 to 2018 (g/mi)

Manufacturer	Model Year 2012			Model Year 2018		
	Car	Truck	All	Car	Truck	All
BMW	277	363	302	253	304	268
BYD Motors	0	-	0	0	-	0
FCA	300	384	357	302	332	327
Ford	261	385	315	253	343	315
GM	283	397	331	234	348	309
Honda	237	320	266	203	269	229
Hyundai	243	312	249	241	340	245
Jaguar Land Rover	376	439	426	269	322	317
Kia	258	324	266	233	320	253
Mazda	241	324	263	225	261	239
Mercedes	316	393	343	269	335	299
Mitsubishi	262	283	267	197	252	229
Nissan	258	382	295	225	313	257
Subaru	257	296	282	244	239	240
Tesla	0	-	0	0	0	0
Toyota	221	354	273	216	324	273
Volkswagen	274	330	281	257	300	282
Volvo	297	343	311	247	279	272
All Manufacturers	**259**	**369**	**302**	**228**	**320**	**280**

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Figure 5.4

Model Year 2018 Production of EVs, PHEVs, and FCVs

Manufacturer	Production of EV/FCV (2.0x)	Production of PHEV (1.6x)
BMW	1,765	25,585
BYD Motors	2	-
FCA	990	13,417
Ford	322	6,245
GM	9,879	20,949
Honda	840	24,156
Hyundai	244	1,181
Jaguar Land Rover	-	-
Kia	603	3,815
Mazda	-	-
Mercedes	1,293	2,232
Mitsubishi	-	5,353
Nissan	13,347	-
Subaru	-	-
Tesla	193,102	-
Toyota	1,370	19,199
Volkswagen	526	5,471
Volvo	-	3,935
All Manufacturers	**224,283**	**131,538**

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Figure 5.5

Model Year 2018 Advanced Technology Credits by Manufacturer

Manufacturer	Car (Mg)	Truck (Mg)	Total (Mg)	Total (g/mi)
BMW	409,763	108,392	518,155	6.9
BYD Motors	84	-	84	215.1
FCA	92,564	511,457	604,021	1.5
Ford	245,353	-	245,353	0.5
GM	1,046,633	-	1,046,633	1.8
Honda	600,784	-	600,784	1.8
Hyundai	30,717	-	30,717	0.2
Jaguar Land Rover	-	-	-	-
Kia	87,080	-	87,080	0.8
Mazda	-	-	-	-
Mercedes	69,005	50,907	119,912	1.6
Mitsubishi	38,452	-	38,452	1.4
Nissan	645,943	-	645,943	2.4
Subaru	-	-	-	-
Tesla	8,192,147	449,885	8,642,032	227.9
Toyota	467,692	-	467,692	0.9
Volkswagen	90,556	33,897	124,453	0.8
Volvo	20,955	72,823	93,778	4.5
All Manufacturers	**12,037,728**	**1,227,361**	**13,265,089**	**3.9**

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Figure 5.6
Production of FFVs, Model Year
2012-2018

Model Year	Car	Truck
2012	815,440	1,352,258
2013	791,660	1,701,209
2014	709,192	2,091,685
2015	538,648	1,300,077
2016	429,195	910,075
2017	307,116	859,376
2018	164,578	772,181

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Figure 5.7
FFV Credits by
Model Year (g/mi)

Model Year	GHG Credits
2012	8.1
2013	7.8
2014	8.9
2015	6.4
2016	-
2017	-
2018	-

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Figure 5.8
HFO-1234yf Adoption by Manufacturer (Production Volume)

Manufacturer	Model Year					
	2013	2014	2015	2016	2017	2018
BMW	-	-	-	-	334,633	367,072
BYD Motors	-	-	-	-	-	-
FCA	-	540,098	1,683,956	1,504,046	1,633,139	1,750,652
Ford	-	-	-	-	1,326,663	1,530,469
GM	41,913	30,652	16,298	32,775	1,632,981	2,433,265
Honda	471	599	-	541,393	897,751	1,368,127
Hyundai	-	-	-	-	14,663	211,969
Jaguar Land Rover	-	56,604	62,316	114,580	122,586	110,615
Kia	-	-	-	-	264,353	336,262
Mazda	-	-	-	-	-	-
Mercedes	-	-	-	-	-	-
Mitsubishi	-	-	-	-	-	58,968
Nissan	-	-	-	-	-	94,474
Subaru	-	-	-	-	292,788	228,363
Tesla	-	-	-	-	-	-
Toyota	-	-	-	-	277,645	819,578
Volkswagen	-	-	-	-	50,884	588,194
Volvo	-	-	-	-	-	-
All Manufacturers	42,384	627,953	1,762,570	2,192,794	6,848,086	9,898,008

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Figure 5.9

Fleetwide A/C Credits by Credit Type

Model Year	A/C Leakage Credits (Tg)	A/C Efficiency Credits (Tg)
2009	6.2	2.1
2010	8.3	2.8
2011	8.9	3.6
2012	11.1	5.9
2013	13.1	8.6
2014	16.7	10.6
2015	20.4	12.4
2016	22.3	12.6
2017	32.8	16.2
2018	38.7	17.3

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Figure 5.10
Total A/C Credits by Manufacturer for
Model Year 2018

Manufacturer	A/C Leakage Credits (g/mi)	A/C Efficiency Credits (g/mi)
BMW	14.6	5.2
BYD Motors	-	-
FCA	15.9	5.8
Ford	13.6	5.7
GM	15.4	5.8
Honda	13.4	4.4
Hyundai	5.8	3.5
Jaguar Land Rover	16.9	7.0
Kia	9.1	3.8
Mazda	3.1	-
Mercedes	6.5	6.0
Mitsubishi	10.5	2.4
Nissan	5.6	3.8
Subaru	5.0	4.2
Tesla	5.6	5.1
Toyota	7.3	5.1
Volkswagen	13.3	6.0
Volvo	6.6	5.9
All Manufacturers	**11.3**	**5.0**

Figure 5.11

Off-Cycle Menu Technology Adoption by Manufacturer, Model Year 2018

Manufacturer	Active Aerodynamic Improvements	Active Engine Warmup	Active Transmission Warmup	Engine Idle Start Stop	High Efficiency Lighting	Active Seat Ventilation	Glass Or Glazing	Solar Reflective Coating	Active Cabin Ventilation	Passive Cabin Ventilation
BMW	25%	23%	-	32%	100%	8%	-	-	100%	-
BYD Motors	-	-	-	-	-	-	-	-	-	-
FCA	23%	70%	37%	46%	55%	32%	98%	22%	-	97%
Ford	89%	26%	60%	62%	56%	22%	100%	7%	-	48%
GM	68%	47%	-	43%	93%	19%	100%	23%	-	100%
Honda	39%	8%	92%	7%	100%	7%	98%	-	-	-
Hyundai	2%	2%	77%	2%	60%	11%	87%	19%	-	-
Jaguar Land Rover	78%	-	46%	100%	100%	45%	100%	-	-	78%
Kia	5%	5%	63%	9%	55%	10%	100%	21%	-	-
Mazda	61%	-	95%	-	67%	3%	94%	-	-	-
Mercedes	-	-	-	-	97%	17%	88%	-	-	-
Mitsubishi	-	-	-	4%	87%	-	78%	-	-	-
Nissan	48%	29%	63%	1%	75%	5%	67%	14%	-	-
Subaru	32%	-	87%	-	52%	-	91%	-	-	-
Tesla	100%	-	-	-	100%	-	100%	-	100%	-
Toyota	5%	30%	39%	16%	63%	27%	99%	25%	-	84%
Volkswagen	26%	85%	7%	70%	99%	22%	59%	6%	-	-
Volvo	-	100%	-	100%	100%	9%	-	-	-	100%
All Manufacturers	**40%**	**32%**	**44%**	**29%**	**74%**	**18%**	**90%**	**14%**	**3%**	**48%**

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Figure 5.12

**Total Off-Cycle Credits by Manufacturer for
Model Year 2018**

Manufacturer	Menu Credits (g/mi)	Non-Menu Credits (g/mi)
BMW	5.4	-
BYD Motors	-	-
FCA	9.4	0.5
Ford	9.2	0.6
GM	7.3	1.3
Honda	3.9	-
Hyundai	2.2	0.0
Jaguar Land Rover	10.0	-
Kia	2.5	-
Mazda	2.9	-
Mercedes	1.8	-
Mitsubishi	1.2	-
Nissan	3.2	-
Subaru	3.9	-
Tesla	4.9	-
Toyota	5.3	0.6
Volkswagen	6.3	-
Volvo	10.0	-
All Manufacturers	**6.0**	**0.4**

*Data updated on 3/11/20

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Figure 5.13
Early Credits Reported and Expired by Manufacturer

Manufacturer	Expired 2009 Credits (Tg of CO2)	Used 2009 Credits (Tg of CO2)	Remaining Credits (Tg of CO2)
BMW	0.1	0.4	0.7
BYD Motors	-	-	-
FCA	-	6.3	4.5
Ford	5.9	2.5	7.8
GM	7.0	6.0	12.8
Honda	14.1	-	21.7
Hyundai	4.5	0.1	9.4
Jaguar Land Rover	-	-	-
Kia	2.4	0.8	7.3
Mazda	1.3	0.1	4.1
Mercedes	-	0.1	0.3
Mitsubishi	0.6	0.0	0.8
Nissan	8.2	2.3	7.6
Subaru	0.5	1.1	4.1
Suzuki	0.3	0.2	0.4
Tesla	-	-	0.0
Toyota	29.7	1.6	49.1
Volkswagen	1.4	0.8	4.4
Volvo	-	0.2	0.5

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Figure 5.14

**Performance and Standards by Manufacturer,
2018 Model Year**

Manufacturer	Performance (g/mi)	Standard (g/mi)
Ford	286	278
GM	278	275
FCA	294	271
All Manufacturers	**253**	**252**
Volkswagen	256	245
Mercedes	284	244
Toyota	254	243
Subaru	227	237
Nissan	241	232
Honda	206	232
BMW	236	231
Tesla	-244	228
Mazda	233	227
Kia	237	221
Hyundai	233	211

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Figure 5.15
Total Credits Transactions Through Model Year 2018*

Manufacturer	Expires 2021	Expires 2022	Expires 2023
BMW	2.0	3.5	
Coda	0.0		
FCA	34.4	2.4	8.2
GM	0.0		
Honda	-30.7	-3.5	
Jaguar Land Rover	2.7		
Karma Automotive	0.0		
Mercedes	8.7		
Nissan	-3.5		
Suzuki	-0.4		
Tesla	-6.2	-2.4	-9.2
Toyota	-10.3		
Volkswagen	3.0		1.0

* Small volume manufacturers are not included in the 2019 Automotive
Trends Report. However, transfers of credits by manufacturers shown
above TO small volume manufacturers are shown in this table. Thus,
the net transactions in this table will not sum to zero.

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Figure 5.16
Manufacturer Credit Balance
After Model Year 2018

Manufacturer	Credit Balance Carry to 2019 (Tg CO_2)
Toyota	63.4
Honda	40.5
FCA	23.5
Nissan	23.4
Subaru	18.4
GM	18.1
Hyundai	15.2
Ford	12.6
Tesla	11.0
Mazda	10.1
BMW	6.4
Kia	3.3
Volkswagen	3.0
Mitsubishi	2.3
Volvo	1.1
Mercedes	0.1
Karma Automotive	0.1
BYD Motors	0.0
Jaguar Land Rover	-0.2

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Figure 5.17
Industry Performance and Standards, Credit Generation
and Use

Model Year	Performance (g/mi)	Standard (g/mi)
2012	287	299
2013	278	292
2014	273	287
2015	267	274
2016	271	263
2017	263	258
2018	253	252

Model Year	Credits (Mg)	Credits (Tg)
Early Credits (2009-2011)	157,868,491	158
2012	32,837,047	33
2013	41,977,130	42
2014	43,370,247	43
2015	25,149,505	25
2016	-27,721,443	-28
2017	-16,820,022	-17
2018	-4,449,230	-4
carry to 2019	252,211,725	252

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Table 5.1

Manufacturer Footprint and Standards for Model Year 2018

Manufacturer	Footprint (ft^2)			Standards (g/mi)		
	Car	Truck	All	Car	Truck	All
BMW	47.3	51.1	48.3	212	275	231
BYD Motors	47.9	-	47.9	215	-	215
FCA	48.9	52.8	52.0	220	282	271
Ford	46.6	59.9	55.3	210	308	278
GM	46.4	59.2	54.4	209	308	275
Honda	46.3	49.4	47.4	208	267	232
Hyundai	46.5	49.2	46.6	209	266	211
Jaguar Land Rover	49.1	51.0	50.8	244	287	283
Kia	46.2	49.5	46.9	207	267	221
Mazda	45.6	47.9	46.5	206	260	227
Mercedes	48.3	51.3	49.6	217	276	244
Mitsubishi	41.5	44.2	42.9	192	242	221
Nissan	46.0	51.7	47.8	207	277	232
Subaru	44.9	45.0	45.0	202	246	237
Tesla	50.3	54.8	50.4	225	292	228
Toyota	46.1	51.6	48.8	207	275	243
Volkswagen	45.9	50.5	48.4	206	272	245
Volvo	50.7	52.1	51.8	252	292	283
All Manufacturers	**46.5**	**53.9**	**50.4**	**209**	**286**	**252**

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Table 5.2
Production Multipliers by Model Year

Model Year	Electric Vehicles and Fuel Cell Vehicles	Plug-In Hybrid Electric Vehicles, Dedicated Natural Gas Vehicles, and Dual-Fuel Natural Gas Vehicles
2017	2.0	1.6
2018	2.0	1.6
2019	2.0	1.6
2020	1.75	1.45
2021	1.5	1.3

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Table 5.3

Model Year 2018 Off-Cycle Technology Credits from the Menu, by Manufacturer and Technology (g/mi)

Manufacturer	Active Aero-dynamics	Active Engine Warmup	Active Trans Warmup	Thermal Controls	Engine Start-Stop	High Efficiency Lighting	Total Menu Credits
BMW	0.5	0.6	-	2.4	1.0	0.8	5.4
BYD Motors	-	-	-	-	-	-	-
FCA	0.2	2.1	1.2	3.8	2.0	0.1	9.4
Ford	1.2	0.7	1.7	2.9	2.5	0.2	9.2
GM	0.8	1.1	-	3.6	1.4	0.5	7.3
Honda	0.2	0.2	2.0	1.0	0.3	0.3	3.9
Hyundai	0.0	0.0	1.2	0.8	0.0	0.2	2.2
Jaguar Land Rover	0.5	-	1.4	3.6	4.2	0.8	10.0
Kia	0.0	0.1	1.3	1.0	0.1	0.1	2.5
Mazda	0.2	-	2.1	0.5	-	0.1	2.9
Mercedes	-	-	-	1.1	-	0.7	1.8
Mitsubishi	-	-	-	0.8	0.1	0.3	1.2
Nissan	0.2	0.6	1.3	0.9	0.0	0.2	3.2
Subaru	0.2	-	2.5	1.0	-	0.2	3.9
Tesla	1.1	-	-	3.1	-	0.7	4.9
Toyota	0.0	0.9	0.2	3.2	0.7	0.3	5.3
Volkswagen	0.2	2.2	0.2	0.8	2.3	0.7	6.3
Volvo	-	2.8	-	2.3	4.0	1.0	10.0
All Manufacturers	**0.4**	**0.8**	**1.0**	**2.4**	**1.1**	**0.3**	**6.0**

*Data updated on 3/11/20

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Table 5.4

Model Year 2018 Off-Cycle Technology Credits from an Alternative Methodology, by
Manufacturer and Technology (g/mi)

Manufacturer	Combined Condenser A/C System	Denso SAS A/C Compressor	High-Efficiency Alternator	Active Climate Control Seats	Total Alternative Methodology Credits
FCA	-	-	0.5	-	0.5
Ford	-	-	0.6	-	0.6
GM	-	0.7	0.6	0.0	1.3
Hyundai	0.0	-	-	-	0.0
Toyota	-	0.2	0.3	-	0.6
All Manufacturers	**0.0**	**0.1**	**0.3**	**0.0**	**0.4**

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Table 5.5
Manufacturer Performance in Model Year 2018, All (g/mi)

Manufacturer	2-Cycle Tailpipe	Credits					CH₄ & N₂O Deficit	Performance Value
		FFV	TLAAS	A/C	ATVs	Off-Cycle		
BMW	268	-	-	19.8	6.9	5.4	0.2	236
BYD Motors	0	-	-	-	215.1	-	-	-215
FCA	327	-	-	21.7	1.5	9.9	0.1	294
Ford	315	-	-	19.3	0.5	9.8	0.5	286
GM	309	-	-	21.2	1.8	8.6	0.1	278
Honda	229	-	-	17.7	1.8	3.9	-	206
Hyundai	245	-	-	9.4	0.2	2.3	-	233
Jaguar Land Rover	317	-	-	23.8	-	10.0	-	283
Kia	253	-	-	12.9	0.8	2.5	-	237
Mazda	239	-	-	3.1	-	2.9	-	233
Mercedes	299	-	-	12.5	1.6	1.8	-	284
Mitsubishi	229	-	-	12.9	1.4	1.2	-	213
Nissan	257	-	-	9.5	2.4	3.2	0.0	241
Subaru	240	-	-	9.2	-	3.9	-	227
Tesla	0	-	-	10.7	227.9	4.9	-	-244
Toyota	273	-	-	12.5	0.9	5.8	0.1	254
Volkswagen	282	-	-	19.3	0.8	6.3	0.0	256
Volvo	272	-	-	12.5	4.5	10.0	-	245
All Manufacturers	**280**	**-**	**-**	**16.3**	**3.9**	**6.5**	**0.1**	**253**

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Table 5.6
Industry Performance by Model Year, All (g/mi)

Model Year	2-Cycle Tailpipe	Credits					CH$_4$ & N$_2$O Deficit	Performance Value
		FFV	TLAAS	A/C	ATVs	Off-Cycle		
2012	302	8.1	0.6	6.1		1.0	0.2	287
2013	294	7.8	0.5	6.9		1.1	0.3	278
2014	294	8.9	0.2	8.5		3.3	0.2	273
2015	286	6.4	0.3	9.4		3.4	0.2	267
2016	285	-	-	10.3		3.6	0.1	271
2017	284	-	-	13.7	2.3	5.1	0.2	263
2018	280	-	-	16.3	3.9	6.5	0.1	253

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Table 5.7
Manufacturer Performance in Model Year 2018, Car (g/mi)

Manufacturer	2-Cycle Tailpipe	Credits					CH₄ & N₂O Deficit	Performance Value
		FFV	TLAAS	A/C	ATVs	Off-Cycle		
BMW	253	-	-	18.4	7.8	4.2	0.1	223
BYD Motors	0	-	-	-	215.1	-	-	-215
FCA	302	-	-	18.1	1.3	4.2	0.0	278
Ford	253	-	-	16.0	1.7	4.7	0.2	231
GM	234	-	-	16.7	5.4	6.8	0.1	205
Honda	203	-	-	15.3	3.0	2.5	-	182
Hyundai	241	-	-	9.4	0.2	2.1	-	229
Jaguar Land Rover	269	-	-	18.8	-	6.5	-	244
Kia	233	-	-	13.0	1.1	2.1	-	217
Mazda	225	-	-	2.5	0.0	1.9	-	221
Mercedes	269	-	-	11.0	1.7	1.2	-	255
Mitsubishi	197	-	-	6.4	3.4	0.8	-	186
Nissan	225	-	-	8.9	3.7	2.3	0.1	210
Subaru	244	-	-	6.3	-	1.7	-	236
Tesla	0	-	-	10.7	225.2	4.8	-	-241
Toyota	216	-	-	11.4	1.9	4.4	0.1	198
Volkswagen	257	-	-	15.3	1.4	3.6	0.0	237
Volvo	247	-	-	9.3	4.4	6.7	-	227
All Manufacturers	**228**	**-**	**-**	**13.0**	**7.9**	**3.7**	**0.0**	**204**

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Table 5.8
Industry Performance by Model Year, Car (g/mi)

Model Year	2-Cycle Tailpipe	Credits					CH$_4$ & N$_2$O Deficit	Performance Value
		FFV	TLAAS	A/C	ATVs	Off-Cycle		
2012	259	4.0	0.2	5.4	-	0.6	0.1	249
2013	251	4.0	0.1	6.3	-	0.7	0.3	240
2014	250	4.6	0.1	7.5	-	2.2	0.3	236
2015	243	3.1	0.0	8.1	-	2.3	0.1	230
2016	240	-	-	8.8	-	2.3	0.1	229
2017	235	-	-	10.1	4.5	3.0	0.0	217
2018	228	-	-	13.0	7.9	3.7	0.0	204

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Table 5.9
Manufacturer Performance in Model Year 2018, Truck (g/mi)

Manufacturer	2-Cycle Tailpipe	Credits					CH₄ & N₂O Deficit	Performance Value
		FFV	TLAAS	A/C	ATVs	Off-Cycle		
BMW	304	-	-	23.0	4.9	8.1	0.5	268
FCA	332	-	-	22.5	1.5	11.1	0.1	297
Ford	343	-	-	20.8	-	12.1	0.6	311
GM	348	-	-	23.5	-	9.5	0.1	315
Honda	269	-	-	21.3	-	6.1	-	242
Hyundai	340	-	-	6.9	-	5.4	-	328
Jaguar Land Rover	322	-	-	24.4	-	10.4	-	287
Kia	320	-	-	12.3	-	4.1	-	304
Mazda	261	-	-	4.1	-	4.5	-	252
Mercedes	335	-	-	14.3	1.5	2.4	-	317
Mitsubishi	252	-	-	17.7	-	1.4	-	233
Nissan	313	-	-	10.5	-	5.0	-	298
Subaru	239	-	-	10.0	-	4.5	-	225
Tesla	0	-	-	12.4	292.4	8.3	-	-313
Toyota	324	-	-	13.5	-	7.0	0.1	304
Volkswagen	300	-	-	22.1	0.4	8.2	-	269
Volvo	279	-	-	13.5	4.6	11.0	-	250
All Manufacturers	**320**	**-**	**-**	**19.0**	**0.6**	**8.7**	**0.2**	**292**

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Table 5.10
Industry Performance by Model Year, Truck (g/mi)

Model Year	2-Cycle Tailpipe	Credits					CH$_4$ & N$_2$O Deficit	Performance Value
		FFV	TLAAS	A/C	ATVs	Off-Cycle		
2012	369	14.5	1.3	7.3		1.6	0.3	346
2013	360	13.8	1.1	7.9		1.7	0.3	337
2014	349	14.3	0.3	9.7		4.6	0.1	321
2015	336	10.3	0.6	11.0		4.6	0.2	310
2016	332	-	-	11.8		5.1	0.2	315
2017	330	-	-	17.2	0.2	7.1	0.3	306
2018	320	-	-	19.0	0.6	8.7	0.2	292

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Table 5.11

Credits Earned by Manufacturers in Model Year 2018, All

Manufacturer	Performance Value (g/mi)	Standard (g/mi)	Net Compliance (g/mi)	Production	Credit Surplus/ Shortfall (Mg)
BMW	236	231	5	368,192	-416,713
BYD Motors	-215	215	-430	2	168
FCA	294	271	23	1,888,041	-9,396,315
Ford	286	278	8	2,103,253	-3,762,524
GM	278	275	3	2,669,227	-1,929,023
Honda	206	232	-26	1,626,866	8,598,273
Hyundai	233	211	22	708,227	-3,011,849
Jaguar Land Rover	283	283	0	110,615	-4,901
Kia	237	221	16	509,318	-1,649,692
Mazda	233	227	6	318,835	-385,089
Mercedes	284	244	40	362,680	-2,974,379
Mitsubishi	213	221	-8	126,438	203,923
Nissan	241	232	9	1,327,744	-2,567,935
Subaru	227	237	-10	674,395	1,533,010
Tesla	-244	228	-472	193,102	17,869,526
Toyota	254	243	11	2,443,132	-5,617,632
Volkswagen	256	245	11	729,483	-1,729,374
Volvo	245	283	-38	94,944	791,296
All Manufacturers	**253**	**252**	**1**	**16,254,494**	**-4,449,230**

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Table 5.12

Total Credits Earned in Model Years 2009-2018, All

Model Year	Performance Value (g/mi)	Standard (g/mi)	Net Compliance (g/mi)	Production	Credit Surplus/ Shortfall (Mg)	Credit Expiration
2009	-	-	-	-	98,520,511	2014
2010	-	-	-	-	96,890,664	2021
2011	-	-	-	-	38,769,164	2021
2012	287	299	-12	13,345,155	33,013,724	2021
2013	278	292	-14	15,103,066	42,627,850	2021
2014	273	287	-14	15,478,831	43,325,498	2021
2015	267	274	-7	16,677,789	25,095,159	2021
2016	271	263	8	16,276,424	-27,721,443	2021
2017	263	258	5	17,010,779	-16,600,603	2022
2018	253	252	1	16,254,494	-4,449,230	2023

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Table 5.13
Credits Earned by Manufacturers in Model Year 2018, Car

Manufacturer	Performance Value (g/mi)	Standard (g/mi)	Net Compliance (g/mi)	Production	Credit Surplus/ Shortfall (Mg)
BMW	223	212	11	269,666	-561,953
BYD Motors	-215	215	-430	2	168
FCA	278	220	58	370,666	-4,227,633
Ford	231	210	21	721,024	-2,918,968
GM	205	209	-4	992,131	753,552
Honda	182	208	-26	1,032,136	5,183,156
Hyundai	229	209	20	686,103	-2,703,395
Jaguar Land Rover	244	244	0	12,059	680
Kia	217	207	10	402,888	-770,573
Mazda	221	206	15	203,821	-582,325
Mercedes	255	217	38	208,832	-1,556,906
Mitsubishi	186	192	-6	58,412	63,840
Nissan	210	207	3	895,716	-560,324
Subaru	236	202	34	150,547	-1,001,931
Tesla	-241	225	-466	186,290	16,938,526
Toyota	198	207	-9	1,243,916	2,110,765
Volkswagen	237	206	31	329,216	-1,973,519
Volvo	227	252	-25	24,177	120,015
All Manufacturers	**204**	**209**	**-5**	**7,787,602**	**8,313,175**

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Table 5.14
Total Credits Earned in Model Years 2009-2018, Car

Model Year	Performance Value (g/mi)	Standard (g/mi)	Net Compliance (g/mi)	Production	Credit Surplus/ Shortfall (Mg)	Credit Expiration
2009	-	-	-	-	58,017,205	2014
2010	-	-	-	-	50,856,024	2021
2011	-	-	-	-	8,830,528	2021
2012	249	266	-17	8,628,026	30,564,873	2021
2013	240	260	-20	9,722,724	39,290,512	2021
2014	236	253	-17	9,197,604	30,447,846	2021
2015	230	241	-11	9,597,167	22,061,932	2021
2016	229	231	-2	8,998,957	3,373,702	2021
2017	217	219	-2	8,936,169	2,602,721	2022
2018	204	209	-5	7,787,602	8,313,175	2023

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Table 5.15

Credits Earned by Manufacturers in Model Year 2018, Truck

Manufacturer	Performance Value (g/mi)	Standard (g/mi)	Net Compliance (g/mi)	Production	Credit Surplus/ Shortfall (Mg)
BMW	268	275	-7	98,526	145,240
FCA	297	282	15	1,517,375	-5,168,682
Ford	311	308	3	1,382,229	-843,556
GM	315	308	7	1,677,096	-2,682,575
Honda	242	267	-25	594,730	3,415,117
Hyundai	328	266	62	22,124	-308,454
Jaguar Land Rover	287	287	0	98,556	-5,581
Kia	304	267	37	106,430	-879,119
Mazda	252	260	-8	115,014	197,236
Mercedes	317	276	41	153,848	-1,417,473
Mitsubishi	233	242	-9	68,026	140,083
Nissan	298	277	21	432,028	-2,007,611
Subaru	225	246	-21	523,848	2,534,941
Tesla	-313	292	-605	6,812	931,000
Toyota	304	275	29	1,199,216	-7,728,397
Volkswagen	269	272	-3	400,267	244,145
Volvo	250	292	-42	70,767	671,281
All Manufacturers	**292**	**286**	**6**	**8,466,892**	**-12,762,405**

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Table 5.16
Total Credits Earned in Model Years 2009-2018, Truck

Model Year	Performance Value (g/mi)	Standard (g/mi)	Net Compliance (g/mi)	Production	Credit Surplus/ Shortfall (Mg)	Credit Expiration
2009	-	-	-	-	40,503,306	2014
2010	-	-	-	-	46,034,640	2021
2011	-	-	-	-	29,938,636	2021
2012	346	346	-	4,717,129	2,448,851	2021
2013	337	337	-	5,380,342	3,337,338	2021
2014	321	330	-9	6,281,227	12,877,652	2021
2015	310	311	-1	7,080,622	3,033,227	2021
2016	315	297	18	7,277,467	-31,095,145	2021
2017	306	295	11	8,074,610	-19,203,324	2022
2018	292	286	6	8,466,892	-12,762,405	2023

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Table 5.17

Final Credit Balance by Manufacturer for Model Year 2018 (Mg)

Manufacturer	Early Credits Earned 2009-2011	Credits Earned 2012-2017	Credits Earned 2018	Credits Expired	Credits Forfeited	Credits Purchased or Sold*	Final 2018 Credit Balance
BMW	1,251,522	224,909	-416,713	-134,791	-	5,500,000	6,424,927
BYD Motors	-	5,400	168	-	-	-	5,568
Coda	-	7,251	-	-	-	-7,251	-
FCA	10,827,083	-22,967,481	-9,396,315	-	-	45,054,999	23,518,286
Ford	16,116,453	6,154,294	-3,762,524	-5,882,011	-	-	12,626,212
GM	25,788,547	1,216,402	-1,929,023	-6,998,699	-	7,251	18,084,478
Honda	35,842,334	44,423,035	8,598,273	-14,133,353	-	-34,245,245	40,485,044
Hyundai	14,007,495	8,833,667	-3,011,849	-4,482,649	-169,775	-	15,176,889
Jaguar Land Rover	-	-2,869,661	-4,901	-	-	2,722,736	-151,826
Karma Automotive	-	58,852	-	-	-	-2,841	56,011
Kia	10,444,192	-2,990,314	-1,649,692	-2,362,882	-123,956	-	3,317,348
Mazda	5,482,642	6,335,942	-385,089	-1,340,917	-	-	10,092,578
Mercedes	378,272	-6,004,114	-2,974,379	-	-28,416	8,727,713	99,076
Mitsubishi	1,449,336	1,227,844	203,923	-583,146	-	0	2,297,957
Nissan	18,131,200	19,527,625	-2,567,935	-8,190,124	-	-3,545,570	23,355,196
Porsche	-	426,439	-	-	-426,439	-	-
Subaru	5,755,171	11,636,165	1,533,010	-491,789	-	-	18,432,557
Suzuki	876,650	-183,097	-	-265,311	-	-428,242	-
Tesla	49,772	10,870,056	17,869,526	-	-	-17,831,311	10,958,043
Toyota	80,435,498	28,579,728	-5,617,632	-29,732,098	-	-10,262,431	63,403,065
Volkswagen	6,613,985	-4,247,836	-1,729,374	-1,442,571	-219,419	4,000,000	2,974,785
Volvo	730,187	-380,789	791,296	-	-85,163	-	1,055,531
All Manufacturers	**234,180,339**	**99,884,317**	**-4,449,230**	**-76,040,341**	**-1,053,168**	**-310,192**	**252,211,725**

* The transactions do not net to zero due to transactions with small volume manufacturers excluded from this report.

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Table 5.18

Distribution of Credits by Expiration Date (Mg)

Manufacturer	Final 2018 Credit Balance	Credits Expiring in 2021	Credits Expiring in 2022	Credits Expiring in 2023	Deficit Carried 1 year	Deficit Carried 2 years
BMW	6,424,927	2,623,676	3,656,011	145,240		
BYD Motors	5,568	4,871	529	168		
FCA	23,518,286	12,870,920	2,419,871	8,227,495		
Ford	12,626,212	12,626,212	0	0		
GM	18,084,478	15,044,507	2,286,419	753,552		
Honda	40,485,044	27,814,774	4,071,997	8,598,273		
Hyundai	15,176,889	15,176,889	0	0		
Jaguar Land Rover	-151,826	0	0	0	-5,581	-146,245
Karma Automotive	56,011	56,011	0	0		
Kia	3,317,348	3,317,348	0	0		
Mazda	10,092,578	9,724,291	171,051	197,236		
Mercedes	99,076	99,076	0	0		
Mitsubishi	2,297,957	1,922,105	171,929	203,923		
Nissan	23,355,196	22,846,419	508,777	0		
Subaru	18,432,557	12,706,379	3,191,237	2,534,941		
Tesla	10,958,043	0	2,316,012	8,642,031		
Toyota	63,403,065	59,063,588	2,228,712	2,110,765		
Volkswagen	2,974,785	1,730,640	0	1,244,145		
Volvo	1,055,531	0	264,235	791,296		
All Manufacturers	**252,211,725**	**197,627,706**	**21,286,780**	**33,449,065**	**-5,581**	**-146,245**

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Appendix Table A.1

Comparison of Preliminary and Final Real-World
Fuel Economy Values (mpg)

Model Year	Preliminary Value	Final Value	Final Minus Preliminary
2011	22.8	22.3	-0.5
2012	23.8	23.6	-0.2
2013	24.0	24.2	0.2
2014	24.2	24.1	-0.1
2015	24.7	24.6	-0.2
2016	25.6	24.7	-0.9
2017	25.2	24.9	-0.3
2018	25.4	25.1	-0.3
2019 (prelim)	25.5	-	-

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Appendix Table C.1
Fuel Economy Metrics for the Model Year 2018 Toyota Prius Eco

Fuel Economy Metric	Purpose	City/Highway Weighting	Test Basis	Fuel Economy Value (MPG)		
				City/Hwy	City	Hwy
2-cycle Test (unadjusted)	Basis for manufacturer compliance with standards	55%/45%	2-cycle	81	84	78
Label	Consumer information to compare individual vehicles	55%/45%	5-cycle	56	58	53
Estimated Real-World	Best estimate of real-world performance	43%/57%	5-cycle	55	58	53

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Appendix Table E.1
Model Year 2019 Alternative Fuel Vehicle Powertrain and Range

Manufacturer	Model	Fuel or Powertrain	Alternative Fuel Range (miles)*	Total Range (miles)	Utility Factor
BMW	I3	EV	153	153	-
BMW	I3s	EV	153	153	-
BYD Motors	e6	EV	187	187	-
FCA	500e	EV	84	84	-
GM	Bolt	EV	238	238	-
Honda	Clarity	EV	89	89	-
Hyundai	Ioniq	EV	124	124	-
Hyundai	Kona	EV	258	258	-
Jaguar Land Rover	I-Pace	EV	234	234	-
Kia	Niro	EV	239	239	-
Kia	Soul	EV	111	111	-
Mercedes	smart EQ fortwo (convertible)	EV	57	57	-
Mercedes	smart EQ fortwo (coupe)	EV	58	58	-
Nissan	Leaf 40kWh	EV	150	150	-
Nissan	Leaf 62kWh	EV	226	226	-
Nissan	Leaf SV/SL 62 kWh	EV	215	215	-
Tesla	Model 3 Long Range	EV	325	325	-
Tesla	Model 3 Long Range AWD	EV	310	310	-
Tesla	Model 3 LongRange AWD Performance	EV	310	310	-
Tesla	Model 3 Mid Range	EV	264	264	-
Tesla	Model 3 Standard Range	EV	220	220	-
Tesla	Model 3 Standard Range Plus	EV	240	240	-
Tesla	Model S 100D AWD	EV	335	335	-
Tesla	Model S 75D AWD	EV	259	259	-
Tesla	Model S Long Range AWD	EV	370	370	-
Tesla	Model S Performance (19" Wheels)	EV	345	345	-
Tesla	Model S Performance (21" Wheels)	EV	325	325	-
Tesla	Model S Standard Range AWD	EV	285	285	-
Tesla	Model X 100D AWD	EV	295	295	-
Tesla	Model X 75D AWD	EV	238	238	-
Tesla	Model X Long Range AWD	EV	325	325	-
Tesla	Model X P100D AWD	EV	289	289	-
Tesla	Model X Performance (22" Wheels)	EV	270	270	-
VW	e-Golf	EV	125	125	-
VW	e-tron	EV	204	204	-
Honda	Clarity	FCV	360	360	-
Hyundai	Nexo	FCV	354	354	-
Hyundai	Nexo Blue	FCV	380	380	-
Toyota	Mirai	FCV	312	312	-
BMW	530e	PHEV	16	360	0.39

Manufacturer	Model	Fuel or Powertrain	Alternative Fuel Range (miles)*	Total Range (miles)	Utility Factor
BMW	530e xDrive	PHEV	15	360	0.37
BMW	740e xDrive	PHEV	14	340	0.36
BMW	I3 with Range Extender	PHEV	126	200	0.92
BMW	I3s with Range Extender	PHEV	126	200	0.92
BMW	I8 Coupe	PHEV	18	320	0.42
BMW	I8 Roadster	PHEV	18	320	0.42
BMW	Mini Cooper SE Countryman All4	PHEV	12	270	0.32
FCA	Pacifica	PHEV	32	520	0.61
Ford	Fusion Energi	PHEV	26	610	0.54
Ford	Fusion Special Service Vehicle PHEV	PHEV	26	610	0.54
GM	Volt	PHEV	53	420	0.76
Honda	Clarity	PHEV	48	340	0.73
Hyundai	Ioniq	PHEV	29	630	0.57
Hyundai	Sonata	PHEV	28	600	0.56
Kia	Niro	PHEV	26	560	0.54
Kia	Optima	PHEV	29	610	0.57
Mercedes	GLC 350e 4MATIC	PHEV	10	350	0.33
Mitsubishi	Outlander	PHEV	22	310	0.49
Subaru	Crosstrek AWD	PHEV	17	480	0.42
Toyota	Prius Prime	PHEV	25	640	0.53
Volvo	S60 AWD	PHEV	22	520	0.48
Volvo	S90 AWD	PHEV	21	490	0.48
Volvo	XC60 AWD	PHEV	17	500	0.41
Volvo	XC90 AWD	PHEV	17	490	0.40
VW	Panamera 4 e-Hybrid	PHEV	14	490	0.36
VW	Panamera 4 e-Hybrid Executive	PHEV	14	490	0.36
VW	Panamera 4 e-Hybrid ST	PHEV	14	490	0.36
VW	Panamera Turbo S e-Hybrid	PHEV	14	450	0.35
VW	Panamera Turbo S e-Hybrid Exec	PHEV	14	450	0.35
VW	Panamera Turbo S e-Hybrid ST	PHEV	14	450	0.35

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Appendix Table E.2
Model Year 2019 Alternative Fuel Vehicle Fuel Economy Label Metrics

Manufacturer	Model	Fuel or Powertrain	Charge Depleting			Charge Sustaining	Overall Fuel Economy (mpge)
			Electricity (kW-hrs/ 100 miles)	Gasoline (gallons/ 100 miles)	Fuel Economy (mpge)	Fuel Economy (mpg)	
BMW	I3	EV	30	-	113	-	113
BMW	I3s	EV	30	-	113	-	113
BYD Motors	e6	EV	47	-	72	-	72
FCA	500e	EV	30	-	112	-	112
GM	Bolt	EV	28	-	119	-	119
Honda	Clarity	EV	30	-	114	-	114
Hyundai	Ioniq	EV	25	-	136	-	136
Hyundai	Kona	EV	28	-	120	-	120
Jaguar Land Rover	I-Pace	EV	44	-	76	-	76
Kia	Niro	EV	30	-	112	-	112
Kia	Soul	EV	31	-	108	-	107
Mercedes	smart EQ fortwo (convertible)	EV	33	-	102	-	102
Mercedes	smart EQ fortwo (coupe)	EV	31	-	108	-	108
Nissan	Leaf 40kWh	EV	30	-	112	-	112
Nissan	Leaf 62kWh	EV	31	-	108	-	108
Nissan	Leaf SV/SL 62 kWh	EV	32	-	104	-	104
Tesla	Model 3 Long Range	EV	26	-	130	-	130
Tesla	Model 3 Long Range AWD	EV	29	-	116	-	116
Tesla	Model 3 LongRange AWD Performance	EV	29	-	116	-	116
Tesla	Model 3 Mid Range	EV	27	-	123	-	123
Tesla	Model 3 Standard Range	EV	26	-	131	-	131
Tesla	Model 3 Standard Range Plus	EV	25	-	133	-	133
Tesla	Model S 100D AWD	EV	33	-	102	-	102
Tesla	Model S 75D AWD	EV	33	-	103	-	103
Tesla	Model S Long Range AWD	EV	30	-	111	-	111
Tesla	Model S Performance (19" Wheels)	EV	32	-	104	-	104
Tesla	Model S Performance (21" Wheels)	EV	35	-	97	-	97
Tesla	Model S Standard Range AWD	EV	31	-	109	-	109
Tesla	Model X 100D AWD	EV	39	-	87	-	87
Tesla	Model X 75D AWD	EV	36	-	93	-	93
Tesla	Model X Long Range AWD	EV	35	-	96	-	96
Tesla	Model X P100D AWD	EV	40	-	85	-	85
Tesla	Model X Performance (22" Wheels)	EV	43	-	79	-	79
VW	e-Golf	EV	28	-	119	-	119
VW	e-tron	EV	46	-	74	-	74
Honda	Clarity	FCV	66	-	68	-	68
Hyundai	Nexo	FCV	56	-	57	-	57
Hyundai	Nexo Blue	FCV	60	-	61	-	61
Toyota	Mirai	FCV	66	-	67	-	67
BMW	530e	PHEV	46	0.0	72	29	37

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| Manufacturer | Model | Fuel or Powertrain | Charge Depleting | | | Charge Sustaining | Overall Fuel Economy (mpge) |
			Electricity (kW-hrs/ 100 miles)	Gasoline (gallons/ 100 miles)	Fuel Economy (mpge)	Fuel Economy (mpg)	
BMW	530e xDrive	PHEV	49	0.0	67	28	36
BMW	740e xDrive	PHEV	52	0.0	64	27	33
BMW	I3 with Range Extender	PHEV	32	0.0	100	31	86
BMW	I3s with Range Extender	PHEV	32	0.0	100	31	86
BMW	I8 Coupe	PHEV	49	0.0	69	27	36
BMW	I8 Roadster	PHEV	49	0.0	69	27	36
BMW	Mini Cooper SE Countryman All4	PHEV	51	0.0	65	27	33
FCA	Pacifica	PHEV	41	0.0	82	30	48
Ford	Fusion Energi	PHEV	33	0.0	103	42	61
Ford	Fusion Special Service Vehicle PHEV	PHEV	33	0.0	102	42	60
GM	Volt	PHEV	31	0.0	106	42	79
Honda	Clarity	PHEV	31	0.0	110	42	76
Hyundai	Ioniq	PHEV	28	0.0	119	52	76
Hyundai	Sonata	PHEV	34	0.0	99	39	59
Kia	Niro	PHEV	32	0.0	105	46	66
Kia	Optima	PHEV	33	0.0	103	40	61
Mercedes	GLC 350e 4MATIC	PHEV	59	0.0	56	25	31
Mitsubishi	Outlander	PHEV	45	0.0	74	25	38
Subaru	Crosstrek AWD	PHEV	38	0.0	90	35	46
Toyota	Prius Prime	PHEV	25	0.0	133	54	78
Volvo	S60 AWD	PHEV	43	0.1	74	31	43
Volvo	S90 AWD	PHEV	45	0.1	71	29	41
Volvo	XC60 AWD	PHEV	55	0.1	58	26	33
Volvo	XC90 AWD	PHEV	55	0.1	58	25	33
VW	Panamera 4 e-Hybrid	PHEV	65	0.0	51	23	28
VW	Panamera 4 e-Hybrid Executive	PHEV	65	0.0	51	23	28
VW	Panamera 4 e-Hybrid ST	PHEV	65	0.0	51	23	28
VW	Panamera Turbo S e-Hybrid	PHEV	66	0.1	48	20	25
VW	Panamera Turbo S e-Hybrid Exec	PHEV	66	0.1	48	20	25
VW	Panamera Turbo S e-Hybrid ST	PHEV	66	0.1	48	20	25

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Appendix Table E.3
Model Year 2019 Alternative Fuel Vehicle Label Tailpipe CO$_2$ Emissions Metrics

Manufacturer	Model	Fuel or Powertrain	Tailpipe CO$_2$ (g/mile)
BMW	i3	EV	0
BMW	i3s	EV	0
BYD Motors	e6	EV	0
FCA	500e	EV	0
GM	Bolt	EV	0
Honda	Clarity	EV	0
Hyundai	Ioniq	EV	0
Hyundai	Kona	EV	0
Jaguar Land Rover	I-Pace	EV	0
Kia	Niro	EV	0
Kia	Soul	EV	0
Mercedes	smart EQ fortwo (convertible)	EV	0
Mercedes	smart EQ fortwo (coupe)	EV	0
Nissan	Leaf 40kWh	EV	0
Nissan	Leaf 62kWh	EV	0
Nissan	Leaf SV/SL 62 kWh	EV	0
Tesla	Model 3 Long Range	EV	0
Tesla	Model 3 Long Range AWD	EV	0
Tesla	Model 3 LongRange AWD Performance	EV	0
Tesla	Model 3 Mid Range	EV	0
Tesla	Model 3 Standard Range	EV	0
Tesla	Model 3 Standard Range Plus	EV	0
Tesla	Model S 100D AWD	EV	0
Tesla	Model S 75D AWD	EV	0
Tesla	Model S Long Range AWD	EV	0
Tesla	Model S Performance (19" Wheels)	EV	0
Tesla	Model S Performance (21" Wheels)	EV	0
Tesla	Model S Standard Range AWD	EV	0
Tesla	Model X 100D AWD	EV	0
Tesla	Model X 75D AWD	EV	0
Tesla	Model X Long Range AWD	EV	0
Tesla	Model X P100D AWD	EV	0
Tesla	Model X Performance (22" Wheels)	EV	0
VW	e-Golf	EV	0
VW	e-tron	EV	0
Honda	Clarity	FCV	0
Hyundai	Nexo	FCV	0
Hyundai	Nexo Blue	FCV	0
Toyota	Mirai	FCV	0
BMW	530e	PHEV	193

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Manufacturer	Model	Fuel or Powertrain	Tailpipe CO_2 (g/mile)
BMW	530e xDrive	PHEV	200
BMW	740e xDrive	PHEV	214
BMW	I3 with Range Extender	PHEV	22
BMW	I3s with Range Extender	PHEV	22
BMW	I8 Coupe	PHEV	191
BMW	I8 Roadster	PHEV	191
BMW	Mini Cooper SE Countryman All4	PHEV	223
FCA	Pacifica	PHEV	119
Ford	Fusion Energi	PHEV	99
Ford	Fusion Special Service Vehicle PHEV	PHEV	101
GM	Volt	PHEV	51
Honda	Clarity	PHEV	57
Hyundai	Ioniq	PHEV	74
Hyundai	Sonata	PHEV	100
Kia	Niro	PHEV	90
Kia	Optima	PHEV	97
Mercedes	GLC 350e 4MATIC	PHEV	235
Mitsubishi	Outlander	PHEV	174
Subaru	Crosstrek AWD	PHEV	151
Toyota	Prius Prime	PHEV	78
Volvo	S60 AWD	PHEV	149
Volvo	S90 AWD	PHEV	165
Volvo	XC60 AWD	PHEV	210
Volvo	XC90 AWD	PHEV	216
VW	Panamera 4 e-Hybrid	PHEV	255
VW	Panamera 4 e-Hybrid Executive	PHEV	255
VW	Panamera 4 e-Hybrid ST	PHEV	255
VW	Panamera Turbo S e-Hybrid	PHEV	289
VW	Panamera Turbo S e-Hybrid Exec	PHEV	289
VW	Panamera Turbo S e-Hybrid ST	PHEV	289

Appendix Table E.4
Model Year 2019 EV and PHEV Upstream CO$_2$ Emission Metrics Metrics (g/mi)

Manufacturer	Model	Regulatory Class	Fuel or Powertrain	Tailpipe & Total Upstream CO$_2$			Tailpipe & Net Upstream CO$_2$		
				Low (g/mile)	Avg. (g/mile)	High (g/mile)	Low (g/mile)	Avg. (g/mile)	High (g/mile)
BMW	i3	Car	EV	76	141	242	19	83	184
BMW	i3s	Car	EV	76	141	242	19	83	184
BYD Motors	e6	Car	EV	119	221	378	58	160	317
FCA	500e	Car	EV	77	142	243	22	87	188
GM	Bolt	Car	EV	72	134	230	16	77	173
Honda	Clarity	Car	EV	76	140	240	13	77	177
Hyundai	Ioniq	Car	EV	64	118	203	4	58	142
Hyundai	Kona	Car	EV	72	132	227	13	73	168
Jaguar Land Rover	I-Pace	Car	EV	113	209	359	43	139	289
Kia	Niro	Car	EV	77	142	243	16	81	183
Kia	Soul	Car	EV	80	148	253	22	89	195
Mercedes	smart EQ fortwo (convertible)	Car	EV	84	156	268	30	101	213
Mercedes	smart EQ fortwo (coupe)	Car	EV	79	147	251	25	92	197
Nissan	Leaf 40kWh	Car	EV	77	143	245	18	83	185
Nissan	Leaf 62kWh	Car	EV	79	147	251	20	87	192
Nissan	Leaf SV/SL 62 kWh	Car	EV	83	153	262	23	93	202
Tesla	Model 3 Long Range	Car	EV	66	122	210	1	57	144
Tesla	Model 3 Long Range AWD	Car	EV	74	137	235	9	72	169
Tesla	Model 3 LongRange AWD Performance	Car	EV	74	137	235	9	72	169
Tesla	Model 3 Mid Range	Car	EV	70	130	223	5	65	157
Tesla	Model 3 Standard Range	Car	EV	66	122	208	0	56	143
Tesla	Model 3 Standard Range Plus	Car	EV	65	120	206	0	55	140
Tesla	Model S 100D AWD	Car	EV	85	157	269	14	86	198
Tesla	Model S 75D AWD	Car	EV	84	154	265	12	83	193
Tesla	Model S Long Range AWD	Car	EV	77	143	246	6	72	174
Tesla	Model S Performance (19" Wheels)	Car	EV	83	153	263	12	82	192
Tesla	Model S Performance (21" Wheels)	Car	EV	89	164	282	18	93	211
Tesla	Model S Standard Range AWD	Car	EV	79	146	250	8	75	179
Tesla	Model X 100D AWD	Car	EV	99	183	314	26	110	241
Tesla	Model X 100D AWD	Truck	EV	99	183	314	10	94	225
Tesla	Model X 75D AWD	Car	EV	93	171	294	20	99	221
Tesla	Model X 75D AWD	Truck	EV	93	171	294	4	83	205
Tesla	Model X Long Range AWD	Car	EV	90	166	284	17	93	211
Tesla	Model X Long Range AWD	Truck	EV	90	166	284	1	77	195
Tesla	Model X P100D AWD	Car	EV	101	187	321	29	114	248
Tesla	Model X P100D AWD	Truck	EV	101	187	321	12	98	232
Tesla	Model X Performance (22" Wheels)	Car	EV	110	202	347	37	130	274
Tesla	Model X Performance (22" Wheels)	Truck	EV	110	202	347	21	114	258
VW	e-Golf	Car	EV	73	134	230	15	77	173
VW	e-tron	Car	EV	117	216	370	48	147	301
BMW	530e	Car	PHEV	287	326	386	212	251	311
BMW	530e xDrive	Car	PHEV	297	336	398	221	261	322
BMW	740e xDrive	Car	PHEV	316	357	420	235	276	340
BMW	i3 with Range Extender	Car	PHEV	103	167	266	44	108	208
BMW	i3s with Range Extender	Car	PHEV	103	167	266	44	108	208
BMW	i8 Coupe	Car	PHEV	291	336	406	215	260	330

53

ED_006488A_00003717-00210

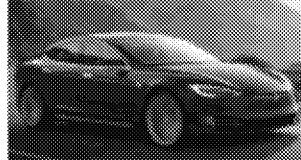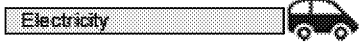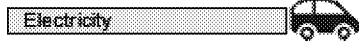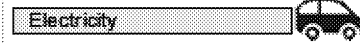| Manufacturer	Model	Regulatory Class	Fuel or Powertrain	Tailpipe & Total Upstream CO_2			Tailpipe & Net Upstream CO_2		
				Low (g/mile)	Avg. (g/mile)	High (g/mile)	Low (g/mile)	Avg. (g/mile)	High (g/mile)
BMW	I8 Roadster	Car	PHEV	291	336	406	215	260	330
BMW	Mini Cooper SE Countryman All4	Car	PHEV	321	356	412	246	281	337
FCA	Pacifica	Truck	PHEV	213	267	351	126	180	265
Ford	Fusion Energi	Car	PHEV	170	208	269	110	148	209
Ford	Fusion Special Service Vehicle PHEV	Car	PHEV	172	211	271	112	150	211
GM	Volt	Car	PHEV	124	176	256	66	117	197
Honda	Clarity	Car	PHEV	129	178	255	69	119	195
Hyundai	Ioniq	Car	PHEV	134	168	222	80	115	169
Hyundai	Sonata	Car	PHEV	174	216	281	113	154	219
Kia	Niro	Car	PHEV	157	194	253	101	139	197
Kia	Optima	Car	PHEV	170	211	274	108	149	213
Mercedes	GLC 350e 4MATIC	Truck	PHEV	344	386	452	256	299	365
Mitsubishi	Outlander	Truck	PHEV	274	321	396	194	242	316
Subaru	Crosstrek AWD	Truck	PHEV	229	264	317	161	195	249
Toyota	Prius Prime	Car	PHEV	131	160	205	80	109	154
Volvo	S60 AWD	Car	PHEV	239	284	354	172	217	286
Volvo	S90 AWD	Car	PHEV	261	308	380	187	234	306
Volvo	XC60 AWD	Truck	PHEV	320	368	444	233	282	357
Volvo	XC90 AWD	Truck	PHEV	327	375	450	238	286	361
VW	Panamera 4 e-Hybrid	Car	PHEV	378	429	508	290	340	419
VW	Panamera 4 e-Hybrid Executive	Car	PHEV	378	429	508	288	339	418
VW	Panamera 4 e-Hybrid ST	Car	PHEV	378	429	508	290	340	419
VW	Panamera Turbo S e-Hybrid	Car	PHEV	421	472	551	324	375	454
VW	Panamera Turbo S e-Hybrid Exec	Car	PHEV	421	472	551	323	374	453
VW	Panamera Turbo S e-Hybrid ST	Car	PHEV	421	472	551	324	375	454
	Average Car	Car		**366**	**366**	**366**	**293**	**293**	**293**

From: Good, David [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP
(FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=6A0A212FAB8644B89798966A2FFF3AB8-GOOD, DAVID]
Sent: 5/13/2021 6:21:17 PM
To: Rojeck, Tristin [rojeck.tristin@epa.gov]
Subject: FW: EV Charge times
Attachments: EVs & FCVs- all 2017 and later EVs & FCVs5-10-2021 TR-backup.xlsx

Tristin,

Yes, I worked with Tesla (Suraj mostly) to add multiple charge times to the dataset, which did appear on fe.gov for 2019 and prior Tesla models. It doesn't include all available Tesla chargers, but does include the most popular option (Dual charger option---but not supercharger charge times, as I remember).

Suit yourself as to whether to update the 2020 and 2021MY Tesla's. It's pretty easy to do since Tesla includes the charge times in the comments field. I can help if you want. Here's an example of what appears on the web for the 2019 and earlier Teslas.

X **2019 Tesla Model S Long Range**	X **2019 Tesla Model S 100D**	X **2019 Tesla Model S Performance (21in Wheels)**	
Electric Vehicle	Electric Vehicle	Electric Vehicle	Add a Vehicle
Automatic (A1) MSRP: $79,990	Automatic (A1)	Automatic (A1)	
Electricity	Electricity	Electricity	

Personalize

Vehicle Specification Data			
EPA Size Class ⓘ	Large Cars	Large Cars	Large Cars
Drive	All-Wheel Drive	All-Wheel Drive	All-Wheel Drive
Stop-Start Technology	No	No	No
Cylinder Deactivation			
Gas Guzzler	No	No	No
Turbocharger	No	No	No
Supercharger	No	No	No
Passenger Volume	94 ft³ (Hatchback)	94 ft³ (Hatchback)	94 ft³ (Hatchback)
Luggage Volume	26 ft³ (Hatchback)	26 ft³ (Hatchback)	26 ft³ (Hatchback)
Fuel Type	Electricity	Electricity	Electricity
Engine Descriptor ⓘ			
Transmission Descriptor ⓘ			
Electric Motor/Battery ⓘ	193 and 205 kW AC 3-Phase	193 (front) 193 (rear) (100 kW-hr battery pack)	193 and 205 kW AC 3-Phase

	12 hrs at 240V (standard charger) 8 hrs at 240V (with 72A high power charger connector option)	12 hrs at 240V (standard charger) 4.75 hrs at 240V (with 80A dual charger option)	12 hrs at 240V (standard charger) 8 hrs at 240V (with 72A high power charger connector option)
Time to Charge Battery			

Stay safe

Dave
734-646-0033 (cell)

From: Rojeck, Tristin <rojeck.tristin@epa.gov>
Sent: Thursday, May 13, 2021 12:48 PM
To: Good, David <good.david@epa.gov>
Subject: RE: EV Charge times

Hi Dave,

So I talked to Bill this morning. VW's intent is not to put two charge time on the window sticker, but he wants to do what Tesla currently does on FE.gov (seen below). Basically, depending on charge rate, there may be different charge times associated with 240V chargers. Tesla puts this in the comments field.

Vehicle Specification Data	
EPA Size Class	Midsize Cars
Drive	All-Wheel Drive
Stop-Start Technology	No
Cylinder Deactivation	
Gas Guzzler	No
Turbocharger	No
Supercharger	No
Passenger Volume	97 ft³ (4 door)
Luggage Volume	15 ft³ (4 door)
Fuel Type	Electricity
Engine Descriptor	
Transmission Descriptor	
Electric Motor/Battery	98 and 195 kW AC 3-Phase
Time to Charge Battery	11.2 hrs at 240V (standard charger) 9.3 hrs at 240V (with 48A high power charger connector option)

This is news to me that we allow Tesla to state a standard charger charge time compared to the high power charger, but I am alright with this practice. Regardless, Tesla puts on their window sticker the charge time for the "standard charger" as input in column "FD" in the *EVs-OK to Release* tab of the attached document.

Does this make sense to you?

Thanks,

Tristin

From: Good, David <good.david@epa.gov>
Sent: Wednesday, May 12, 2021 1:44 PM
To: Rojeck, Tristin <rojeck.tristin@epa.gov>
Subject: RE: EV Charge times

Tristin,

I'm not aware of any mfrs who list multiple charge times on one window sticker. I don't think Tesla does this.

However, if the vehicle is equipped with an optional charger, then two window stickers are required, one with the standard charger and one with the optional charger, like the 2019 Volt. See the attached 2019 Volt labels---some have a charge time of 2.3 hours (with the optional 7.2 kW charger) and some have 4.5 hrs (with the standard 3.6 kW charger).

Dave

From: Rojeck, Tristin <rojeck.tristin@epa.gov>
Sent: Wednesday, May 12, 2021 11:17 AM
To: Good, David <good.david@epa.gov>
Subject: FW: EV Charge times

Hi Dave,

Do you have any examples for Bill on this one? Otherwise, I will do some research and respond to him.

Thanks,

Tristin

From: Rodgers, William (EEO) <William.Rodgers@vw.com>
Sent: Wednesday, May 12, 2021 11:01 AM
To: Rojeck, Tristin <rojeck.tristin@epa.gov>
Subject: EV Charge times

Hi Tristin,
I'm looking for a bit of insight on displaying two 240v charge times for EV's. I see on fueleconomy.gov web site it doesn't appear to be a problem to list multiple charge times but I'm wondering if you may have seen an example of a Monroney label with similar information?

Regards,

Bill Rodgers

Sr Engineer, Emissions Compliance
Engineering and Environmental Office

Volkswagen Group of America, Inc.
3800 Hamlin Road
Auburn Hills, MI 48326
United States of America

T +1 248 754 4219
email: william.rodgers@vw.com

www.vw.com
www.audiusa.com
www.bentleymotors.com
www.lamborghini.com
www.bugatti.com

From: Good, David [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP
(FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=6A0A212FAB8644B89798966A2FFF3AB8-GOOD, DAVID]
Sent: 8/11/2021 7:19:19 PM
To: Hopson, Janet [hopsonjl@ornl.gov]; Gibson, Robert [gibsonrc@ornl.gov]; Davis, Stacy [davissc@ornl.gov]; Laughlin,
Michael [michael.laughlin@ee.doe.gov]; Bunker, Amy [Bunker.Amy@epa.gov]; Dafoe, Wendy
[wendy.dafoe@nrel.gov]; Pugliese, Holly [pugliese.holly@epa.gov]; Wehrly, Linc [wehrly.linc@epa.gov]; Rojeck,
Tristin [rojeck.tristin@epa.gov]; Graff, Michelle [graff.michelle@epa.gov]; Kimball, Joshua [kimball.joshua@epa.gov];
Moses, Darryl [moses.darryl@epa.gov]
Subject: RE: 2022MY Fuel Economy Guide - Text edits
Attachments: djg edits-DRAFT FEG 2022 Text-from Janet 7-19-2021.docx

Janet,

Attached are some minor suggestions for the text for the 2022MY FE Guide, using track changes & comments. Mostly minor edits,
except:
- I tried to re-write item 4 of the Tips for EVs & Hybrid vehicles on page 6---to point out some (little known) tips to increase
the hybrid battery life;
- Also, we need to think about what to say in the Federal Tax Incentives Section (up to $7500 for EVs, PHEVs, etc) on pages 3,
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Also, for the Alt Fueling Station Locator map on page 5, I'm OK with the trip from Washington D.C. to Ann Arbor----but if
you want to revise it, I'd vote for showing the number of EV charging stations between San Francisco or Sacramento and
Seattle. I hear there are quite a few Teslas & EVs in the Seattle area.

Stay safe and go electric!

Dave
734-646-0033 (cell)

From: Hopson, Janet <hopsonjl@ornl.gov>
Sent: Monday, July 19, 2021 8:30 AM
To: Gibson, Robert <gibsonrc@ornl.gov>; Good, David <good.david@epa.gov>; Davis, Stacy <davissc@ornl.gov>;
Laughlin, Michael <michael.laughlin@ee.doe.gov>; Bunker, Amy <Bunker.Amy@epa.gov>; Dafoe, Wendy
<wendy.dafoe@nrel.gov>; Pugliese, Holly <pugliese.holly@epa.gov>; Wehrly, Linc <wehrly.linc@epa.gov>; Rojeck,
Tristin <rojeck.tristin@epa.gov>; Graff, Michelle <graff.michelle@epa.gov>; Kimball, Joshua <kimball.joshua@epa.gov>;
Moses, Darryl <moses.darryl@epa.gov>
Subject: Fuel Economy Guide Call - Agenda and Related Documents

Good Morning Everyone:

Reminder: We will have our first FEG call tomorrow (Tuesday July 20th at 2:00 PM).

Attached is the proposed timeline for the 2022 FEG and a word file containing the **2021** FEG Text. We have **not yet**
updated the graphics, fuel prices, number of alternative fueling stations, etc. Also, the conversion to word isn't perfect so
some of the text may not line up as in the actual guide.

Below is the agenda + call-in information. Please let me know if you have any questions or if you would like to add anything to the agenda.

Tentative Agenda
1.   New DOE Project Manager – Mike Laughlin
2.   2021 Fuel Economy Guide – printed copies
3.   2022 FEG Timeline – Key dates
4.   Request Text Review/Comments
5.   Cover Suggestions
6.   Schedule and format for next call (TEAMS or ZOOM?)

Dial: [Ex. 6 Personal Privacy (PP)]
Enter passcode: [Ex. 6 Personal Privacy (PP)]

Best Regards,

Janet Hopson
Mobile – 865-201-3969

From:	Good, David [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=6A0A212FAB8644B89798966A2FFF3AB8-GOOD, DAVID]
Sent:	8/19/2021 1:00:33 PM
To:	Bunker, Amy [Bunker.Amy@epa.gov]
CC:	Burke, Susan [Burke.Susan@epa.gov]
Subject:	FW: 2022MY Fuel Economy Guide - Text edits
Attachments:	djg edits-DRAFT FEG 2022 Text-from Janet 7-19-2021.docx

Amy,

Yes, I liked your EV write-up.

Regarding battery charging tips, I wasn't happy with my write-up and was hoping that ORNL staff (or you) would edit it a little. It tends to repeat the message (and makes the same point 3 or 4 times).

Technically, it is accurate---it was one of the durability factors mentioned by almost all of the 12 mfrs which we met with over the last 5 years or so (mfrs of HEV/EV/PHEVs).

While not battery durability is mentioned in the vehicle owner's manuals---some of the electric leaf blowers, lawnmowers, hedge trimmers, etc. discuss not to store their Li-Ion batteries at 100% charge in their owner's manuals. My EGO electric leaf blower has a way to discharge the Li-Ion battery if it is stored for moderately long period of time at a high SOC---I'm not sure but I think the charge is automatically reduced to 50% or 70% or so for storage.

One year, Nissan had an option where the customer could recharge to 80% of capacity (to increase battery life) or to 100%----but EPA decided that we would use an average driving range based on the average of an 80% charge and a 100% charge---so Nissan quit offering that option). Rivian may offer something similar to the Leaf (also to increase the life of their battery)----if I can convince EPA staff not to reduce the electric driving range like we did for the Leaf.

Thanks for your comments.

Stay safe and go electric!

Dave
734-646-0033 (cell)

From: Bunker, Amy <Bunker.Amy@epa.gov>
Sent: Tuesday, August 17, 2021 10:58 AM
To: Good, David <good.david@epa.gov>
Cc: Burke, Susan <Burke.Susan@epa.gov>
Subject: RE: 2022MY Fuel Economy Guide - Text edits

Hi Dave,

I am copying in Susan as she is the CASC go-to person on EVs.

Thanks for your response on the battery charging tips list on page 6. My concern is that the tips list seems very prescriptive. I would have assumed that some of the tips might vary by battery management system design, battery chemistry, architecture, etc, so I am wondering if it would be better to just say, "To increase the life of the battery follow the charging and operating instructions provided in your owner's manual." If DOE has a website that discusses this topic we could also link to that site.

Also for your page 2 suggestions, what would you think of this instead: "Electric vehicles typically have a smaller carbon footprint than gasoline cars, even when accounting for the electricity used for charging. EPA and DOE's Beyond Tailpipe Emissions Calculator can help you estimate the greenhouse gas emissions associated with charging and driving an EV or a plug-in hybrid electric vehicle (PHEV) where you live. You can select an EV or PHEV model and type in your zip code to see the CO_2 emissions and how they stack up against those associated with a gasoline car."

Thanks,
Amy

From: Good, David <good.david@epa.gov>
Sent: Tuesday, August 17, 2021 10:08 AM
To: Bunker, Amy <Bunker.Amy@epa.gov>
Subject: RE: 2022MY Fuel Economy Guide - Text edits

Hi Amy,

Those tips to increase battery life come from our "EV/HEV/PHEV battery durability" meetings with the 10-12 BEV & PHEV mfrs that CD has held over the past 4-5 years. Attached is a document which I have sent to most of these mfrs (in one version or another). It is currently in the form of a DRAFT EPA Guidance letter----but it was never finalized. See the questions in the attachment.

One tip which I decided not to include---was to recharge the vehicle as slow as possible----in the following hierarchy: 120V charging, then 240V then DC Fast charging. Fast charging is not good for battery life----it depends on how the mfr cools the battery when recharging, etc. [High battery temperatures during recharging, etc is not good for battery durability. [I'll let mfrs provide that info to their customers if they want-----We'll see what mfrs recommend to customers when CARB requires hybrid batteries to be warranted for 150K miles in their next round of ZEV/GHG regulations.]

I have a giant CONFIDENTIAL spreadsheet with the mfrs answers to the battery durability questions----let me know if you would like me to send you a copy.

Stay safe and go electric!

Dave
734-646-0033 (cell)

From: Bunker, Amy <Bunker.Amy@epa.gov>
Sent: Monday, August 16, 2021 3:32 PM
To: Good, David <good.david@epa.gov>
Subject: RE: 2022MY Fuel Economy Guide - Text edits

Hi Dave,

Thanks for taking the time to work on the text of the Guide. I was wondering whether you were using a DOE source or something else for the tips to increase hybrid battery life?

Thanks,
Amy

From: Good, David <good.david@epa.gov>
Sent: Wednesday, August 11, 2021 3:19 PM
To: Hopson, Janet <hopsonjl@ornl.gov>; Gibson, Robert <gibsonrc@ornl.gov>; Davis, Stacy <davissc@ornl.gov>; Laughlin, Michael <michael.laughlin@ee.doe.gov>; Bunker, Amy <Bunker.Amy@epa.gov>; Dafoe, Wendy <wendy.dafoe@nrel.gov>; Pugliese, Holly <pugliese.holly@epa.gov>; Wehrly, Linc <wehrly.linc@epa.gov>; Rojeck, Tristin <rojeck.tristin@epa.gov>; Graff, Michelle <graff.michelle@epa.gov>; Kimball, Joshua <kimball.joshua@epa.gov>; Moses, Darryl <moses.darryl@epa.gov>
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Sent: Monday, July 19, 2021 8:30 AM
To: Gibson, Robert <gibsonrc@ornl.gov>; Good, David <good.david@epa.gov>; Davis, Stacy <davissc@ornl.gov>; Laughlin, Michael <michael.laughlin@ee.doe.gov>; Bunker, Amy <Bunker.Amy@epa.gov>; Dafoe, Wendy <wendy.dafoe@nrel.gov>; Pugliese, Holly <pugliese.holly@epa.gov>; Wehrly, Linc <wehrly.linc@epa.gov>; Rojeck, Tristin <rojeck.tristin@epa.gov>; Graff, Michelle <graff.michelle@epa.gov>; Kimball, Joshua <kimball.joshua@epa.gov>; Moses, Darryl <moses.darryl@epa.gov>
Subject: Fuel Economy Guide Call - Agenda and Related Documents

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Dial: Ex. 6 Personal Privacy (PP)
Enter passcode: Ex. 6 Personal Privacy (PP)

Best Regards,

Janet Hopson
Mobile – 865-201-3969

From:	Good, David [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=6A0A212FAB8644B89798966A2FFF3AB8-GOOD, DAVID]
Sent:	2/11/2019 11:14:12 PM
To:	Hicks, Maurice (NHTSA) [Maurice.Hicks@dot.gov]
CC:	Zaremski, Sara [zaremski.sara@epa.gov]; Rojeck, Tristin [rojeck.tristin@epa.gov]; Finneran, John (NHTSA) [John.Finneran@dot.gov]; French, Roberts [french.roberts@epa.gov]; Kevin Ennis (kevin.ennis.ctr@dot.gov) [kevin.ennis.ctr@dot.gov]; Wehrly, Linc [wehrly.linc@epa.gov]
Subject:	RE: Follow-up to our 2/5/2019 Phone call [Tesla 518.7 mpg--my Ideas attached for your Wed (2/13/2019) EPA/NHTSA meeting
Attachments:	Incremental CAFE mpg adjustment for AC-OC-PU GHG Credits-d.good-2-11-2019.docx

Maurice,

Attached is a white paper with my thoughts about the incremental CAFE mpg credit calculations for 2017 Tesla and Ford IPC CAFEs.

Ex. 5 Deliberative Process (DP)

I'll call you to discuss my ideas. See attached.

Dave

From: Good, David
Sent: Wednesday, January 30, 2019 1:23 PM
To: Wehrly, Linc <wehrly.linc@epa.gov>
Cc: Zaremski, Sara <zaremski.sara@epa.gov>; Rojeck, Tristin <rojeck.tristin@epa.gov>; 'Hicks, Maurice (NHTSA)' <Maurice.Hicks@dot.gov>; Finneran, John (NHTSA) <John.Finneran@dot.gov>; French, Roberts <french.roberts@epa.gov>; Kevin Ennis (kevin.ennis.ctr@dot.gov) <kevin.ennis.ctr@dot.gov>
Subject: RE: 2016 and 2017 CAFE Status as of 1/30/2019

Linc,

<u>Status of 2016 CAFE/GHG letters:</u> The 2016 CAFE/GHG EPA letters have all been issued, except for VW Group. The

Ex. 5 Deliberative Process (DP)

<u>Status of 2017 CAFE/GHG letters:</u> See the attachment. Notes:
*   Column L: If the EPA CAFE letter has not been issued (column L is blank) please disregard the Comments in Column L---as those comments apply to the 2016MY CAFE.
*   Column Q contains a "Yes/No" field indicating whether the <u>GHG values</u> are final (or whether the GHG fleet average compliance value will need to be revised in the summer of 2019 or so---due to EPA's ongoing multiplier

rulemaking (only impacts GHG fleet average calculations with EVs, PHEVs, FCVs or CNG vehicles). [CAFE values are not affected.]

2017 CAFE/GHG letters in process: As of 1/30/2019, the following CAFE/GHG letters were partially done, but are waiting for more information from the manufacturer:
Ford;
Toyota;
Ferrari.

They should be finished in a week or so (hopefully before Feb 15, 2019).

2016-17 CAFE/GHG letters waiting for NHTSA guidance: The following 2016 and 2017 CAFE/GHG letters cannot be done until EPA receives additional information from NHTSA:

MY	Manufacturer	Combined or Separate?	Guidance needed from NHTSA
2017	Nissan/Mitsubishi; Nissan/Mitsubishi);	Combined	EPA is waiting for a copy of NHTSA's final letter to
2017	Volvo/Lotus; Volvo/Lotus (Geely);	Combined	EPA is waiting for a copy of NHTSA's final letter to
2017	Hyundai/Kia; Hyundai/Kia staff;	Separate	EPA is waiting for Maurice's email message to
2016	VW Group	NA	EPA is waiting for NHTSA's concurrence not to

adjust the fuel economy and GHG values of 2016 diesel vehicles.

After receiving NHTSA guidance, it will take Nissan/Mitsubishi and Volvo/Lotus a month or two to combine the data in EPA's database and send EPA an official (combined) 2017 model year report---then it will take EPA a week or so to review the data and issue the official CAFE letter. For Hyundai/Kia, it will take EPA a week or two to review the data and issue the official CAFE letter---EPA will start our review the week of Feb 4, 2019.

I'm cc'ing NHTSA staff. Maurice, I'll call you to discuss.

Dave

From: Hicks, Maurice (NHTSA) <Maurice.Hicks@dot.gov>
Sent: Friday, December 21, 2018 10:47 AM
To: Good, David <good.david@epa.gov>; Finneran, John (NHTSA) <John.Finneran@dot.gov>; French, Roberts <french.roberts@epa.gov>
Cc: Wehrly, Linc <wehrly.linc@epa.gov>; Zaremski, Sara <zaremski.sara@epa.gov>; Rojeck, Tristin <rojeck.tristin@epa.gov>
Subject: Re: 2017 CAFE - Nissan/Mitsubishi; Volvo/Lotus, Hyundai/Kia Status

Ex. 4 CBI

Get Outlook for iOS

From: Good, David <good.david@epa.gov>
Sent: Thursday, December 20, 2018 2:53:20 PM
To: Hicks, Maurice (NHTSA); Finneran, John (NHTSA); French, Roberts

Cc: Wehrly, Linc; Zaremski, Sara; Rojeck, Tristin
Subject: 2017 CAFE - Nissan/Mitsubishi; Volvo/Lotus, Hyundai/Kia Status

Maurice,

Has there been any progress communicating with Nissan, Volvo or the Hyundai/Kia folks regarding whether they should submit combined 2017 CAFE model year reports?

I thought you were going to send the Hyundai/Kia folks an email message on 12/10/2018 or so, delaying NHTSA's decision until the 2018MY CAFEs are due. Keep in mind that the 2018 CAFEs are due relatively soon (3/31/2019).

Thanks

Dave

From: Hicks, Maurice (NHTSA) <Maurice.Hicks@dot.gov>
Sent: Tuesday, December 11, 2018 2:20 PM
To: Nakamura-Newbraugh, Yasumi <yasumi.nakamura-newbraugh@Nissan-Usa.com>; Good, David <good.david@epa.gov>; Finneran, John (NHTSA) <John.Finneran@dot.gov>; Matheke, Otto (NHTSA) <Otto.Matheke@dot.gov>; French, Roberts <french.roberts@epa.gov>
Subject: Nissan/Mitsubishi Part 534 MY 2017 CAFE Corporate Relationship

I just wanted to give you a-heads up that, even though I thought we would be able to release NHTSA's legal response on the Nissan and Mitsubishi combined CAFE relationship for MY 2017, NHTSA's Chief Counsel needs to be briefed by Otto on the issues and Otto is out of the office until next week. As soon as Otto returns, we'll try to get the letter out to you as soon as possible. I apologize for the inconvenience. Thanks

Maurice

Maurice Hicks
Senior Compliance Engineer
NHTSA, OVSC Enforcement Fuel Efficiency Group, NEF-221
(202)366-1708
maurice.hicks@dot.gov

From: Good, David [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP
(FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=6A0A212FAB8644B89798966A2FFF3AB8-GOOD, DAVID]
Sent: 7/30/2019 10:51:55 PM
To: Rojeck, Tristin [rojeck.tristin@epa.gov]; Graff, Michelle [graff.michelle@epa.gov]; French, Roberts
[french.roberts@epa.gov]; Bunker, Amy [Bunker.Amy@epa.gov]; Kimball, Joshua [kimball.joshua@epa.gov]
CC: Snapp, Lisa [snapp.lisa@epa.gov]; Wehrly, Linc [wehrly.linc@epa.gov]; Pugliese, Holly [pugliese.holly@epa.gov];
Zaremski, Sara [zaremski.sara@epa.gov]
Subject: 2020FE Guide - DRAFT text revisions attached; please comment by COB Aug 6, 2019 or so
Attachments: DRAFT 2020MY-FEGuide-text-from Robert G-7-24-2019(djg).docx

Tristin, Amy, Rob & all,

Attached is my first cut at the 2020MY text revisions for the 2020MY FE Guide. Mostly, I tried to add a description of
mild and strong (full) hybrid vehicles to the Hybrid Electrical Vehicle section. Feel free to edit.

It's due to ORNL on Monday 8/12/2019. I'd like to send it to them on Thurs or Friday Aug 8 or 9th.

Listing Mild Hybrids separately in the 2020 FE Guide:

I'm thinking that there will be quite a few mild hybrids by 2020MY, so that I vote not to list them separately in the 2021
FE Guide (and possibly not in the 2020 FE Guide). [**Ex. 4 CBI**] and many other vehicles will
use the BAS mild hybrid/48v battery systems.

Currently for 2019MY, 19 of 1258 vehicles are mild hybrids (FCA, Mercedes & VW). For 2020MY, 10 of 553 vehicles are
mild hybrids, so far. I'm thinking that in 2021MY there could be 50-100 mild hybrids.

Listing FFVs separately in the 2020 FE Guide:

I'm OK with listing FFVs separately in the 2020 FE Guide. My count of FFVs is as follows:

2014MY −140/1200 models, 2,860,460 LDV/T prodn;
2015MY −98/1254 models, 1,835,381 LDV/T prodn;
2016MY −69/1213 models, 1,333,852 LDV/T prodn;
2017MY −64/1244 models, 1,110,972 LDV/T prodn;
2018MY −54/1286 models, 936,244 LDV/T prodn;
2019MY −43/1258 models; (production not available)
2020MY −13/553 models; (production not available)

Rob is out until Aug 5th.

Please comment by Aug 6, 2019

Thanks

Dave

From: Gibson, Robert <gibsonrc@ornl.gov>
Sent: Wednesday, July 24, 2019 5:05 PM

To: Hopson, Janet <hopsonjl@ornl.gov>; Bluestein, Linda <linda.bluestein@ee.doe.gov>; Bunker, Amy <Bunker.Amy@epa.gov>; Dafoe, Wendy <wendy.dafoe@nrel.gov>; Deitchel, Judi <judi.deitchel@nrel.gov>; French, Roberts <french.roberts@epa.gov>; Good, David <good.david@epa.gov>; Pugliese, Holly <pugliese.holly@epa.gov>; 'Smith, Dennis' <dennis.a.smith@ee.doe.gov>; Wehrly, Linc <wehrly.linc@epa.gov>; West, Brian <westbh@ornl.gov>; Zaremski, Sara <zaremski.sara@epa.gov>; Earles, Colby <earlesc@ornl.gov>; Rojeck, Tristin <rojeck.tristin@epa.gov>; Davis, Stacy <davissc@ornl.gov>
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Please note that we've added some new text: a short paragraph about how the guide is organized and a short write-up highlighting AFDC's Alternative Fueling Station Locator. Both are highlighted in yellow in the text write-up (Word doc), which is also attached.

Also, please note that we've added a back page rather than putting the sample fuel economy label there. It won't matter much to people printing the guide on a printer, but since Dennis likes to print a small batch of guides sometimes, he (or others) might have a preference.

We haven't yet updated things like fuel prices, page references, etc. as is usual at this point.

Please let us know if you have comments or suggestions about either document.

Thanks.

Robert C. Gibson
Center for Transportation Research
University of Tennessee
National Transportation Research Center, Room I-17
2360 Cherahala Blvd.
Knoxville, Tennessee 37932
TEL: 865-946-1481
FAX: 865-946-1314
gibsonrc@ornl.gov
www.fueleconomy.gov

From: Hopson, Janet <hopsonjl@ornl.gov>
Sent: Wednesday, July 24, 2019 1:34 PM
To: Bluestein, Linda <linda.bluestein@ee.doe.gov>; 'Bunker, Amy' <bunker.amy@epa.gov>; Dafoe, Wendy <wendy.dafoe@nrel.gov>; Deitchel, Judi <judi.deitchel@nrel.gov>; 'French, Rob' <french.roberts@epa.gov>; Gibson, Robert <gibsonrc@ornl.gov>; 'Good, David' <good.david@epa.gov>; Hopson, Janet <hopsonjl@ornl.gov>; 'Pugliese, Holly' <pugliese.holly@epa.gov>; 'Smith, Dennis' <dennis.a.smith@ee.doe.gov>; 'Wehrly, Linc' <wehrly.linc@epa.gov>; West, Brian <westbh@ornl.gov>; 'Zaremski, Sara' <zaremski.sara@epa.gov>; Earles, Colby <earlesc@ornl.gov>; Rojeck, Tristin <rojeck.tristin@epa.gov>; Davis, Stacy <davissc@ornl.gov>
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Please let me know if you would like to add anything to the agenda.

Janet

DOE CONFERENCE CALL DIAL-IN INFORMATION	
Call Date	7/25/19
Call Time	9:00-10:00AM
Dial-In Number	Ex. 5 Deliberative Process (DP)
Confirmation Number	Ex. 5 Deliberative Process (DP)
Leader/Conference Name	Brian West
Contact #	Ex. 5 Deliberative Process (DP)
Conference Duration	1 Hour
Number of Callers	UNDER 24
Call-In Instructions	
1.	Callers will dial the call-in number.
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2360 Cherahala Blvd
Knoxville, TN 37932
Phone: 865-946-1460
hopsonjl@ornl.gov
www.fueleconomy.gov

From: Good, David [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP
(FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=6A0A212FAB8644B89798966A2FFF3AB8-GOOD, DAVID]
Sent: 7/24/2019 9:50:52 PM
To: Kimball, Joshua [kimball.joshua@epa.gov]
Subject: FW: Reminder - FEG call tomorrow
Attachments: MY20-FEG-body8.pdf; MY20-FEG-body7-TEXT.docx

FYI

Dave

From: Gibson, Robert [mailto:gibsonrc@ornl.gov]
Sent: Wednesday, July 24, 2019 5:05 PM
To: Hopson, Janet <hopsonjl@ornl.gov>; Bluestein, Linda <linda.bluestein@ee.doe.gov>; Bunker, Amy
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Ex. 6 Personal Privacy (PP)	

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From:	Good, David [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=6A0A212FAB8644B89798966A2FFF3AB8-GOOD, DAVID]
Sent:	8/13/2019 7:02:21 PM
To:	Gibson, Robert [gibsonrc@ornl.gov]; Hopson, Janet [hopsonjl@ornl.gov]; Bluestein, Linda [linda.bluestein@ee.doe.gov]; Bunker, Amy [Bunker.Amy@epa.gov]; Dafoe, Wendy [wendy.dafoe@nrel.gov]; Deitchel, Judi [judi.deitchel@nrel.gov]; French, Roberts [french.roberts@epa.gov]; Pugliese, Holly [pugliese.holly@epa.gov]; 'Smith, Dennis' [dennis.a.smith@ee.doe.gov]; Wehrly, Linc [wehrly.linc@epa.gov]; West, Brian [westbh@ornl.gov]; Zaremski, Sara [zaremski.sara@epa.gov]; Earles, Colby [earlesc@ornl.gov]; Rojeck, Tristin [rojeck.tristin@epa.gov]; Davis, Stacy [davissc@ornl.gov]; Snapp, Lisa [snapp.lisa@epa.gov]; Graff, Michelle [graff.michelle@epa.gov]
Subject:	RE: Text edits attached - let's discuss how to treat HEVs in tomorrows meeting
Attachments:	DRAFT 2020MY-FEGuide-text-from Robert G-7-24-2019(djg).docx

Robert & all,

Attached are my text edits. Feel free to edit.

For the HEV section, I tried to describe the difference between mild hybrids and strong hybrids-----however after it was partially written, we (EPA) folks felt that this section and write-up would not be needed. EPA recommends not having a separate HEV section for several reasons---and moving that mild HEV or strong HEV information into the main body of the Guide and listing the hybrid battery information in the "Notes" section (e.g. MHEV 48V Li-Ion or HEV 207V Li-Ion).

I'd like to discuss how to treat HEVs in tomorrow's meeting. There are a lot of mild hybrid vehicles coming in the next few years, and it doesn't make sense to me to list them in the Hybrid section of the Guide. The 2019 Printed Guide has 20 mild hybrids and 40 strong hybrids listed in that section. For example it doesn't make sense to me to list the 2019 Ram 1500 mild hybrid (19mpg) in the same section as all the 2019 Prius hybrids (46-56 mpg).

Anyway, we can discuss it in tomorrow's meeting and then re-write that section if needed.

Dave

From: Gibson, Robert <gibsonrc@ornl.gov>
Sent: Wednesday, July 24, 2019 5:05 PM
To: Hopson, Janet <hopsonjl@ornl.gov>; Bluestein, Linda <linda.bluestein@ee.doe.gov>; Bunker, Amy <Bunker.Amy@epa.gov>; Dafoe, Wendy <wendy.dafoe@nrel.gov>; Deitchel, Judi <judi.deitchel@nrel.gov>; French, Roberts <french.roberts@epa.gov>; Good, David <good.david@epa.gov>; Pugliese, Holly <pugliese.holly@epa.gov>; 'Smith, Dennis' <dennis.a.smith@ee.doe.gov>; Wehrly, Linc <wehrly.linc@epa.gov>; West, Brian <westbh@ornl.gov>; Zaremski, Sara <zaremski.sara@epa.gov>; Earles, Colby <earlesc@ornl.gov>; Rojeck, Tristin <rojeck.tristin@epa.gov>; Davis, Stacy <davissc@ornl.gov>
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Leader/Conference Name	Brian West
Contact #	Ex. 6 Personal Privacy (PP)
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Number of Callers	UNDER 24

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(FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=6A0A212FAB8644B89798966A2FFF3AB8-GOOD, DAVID]
Sent: 12/11/2019 7:57:55 PM
To: Abeer Windel [abeer.windel@fcagroup.com]
Subject: FW: 2020MY Lincoln Aviator PHEV - When will a new 2020 Test Car list be published and application be published on the DIS ?
Attachments: 2020 testcar 2019-12-11.xlsx

Abeer,

Here's an advance copy of the new 2020 TCL which will be posted soon.

Dave

From: Danzeisen, Karen <Danzeisen.Karen@epa.gov>
Sent: Wednesday, December 11, 2019 2:53 PM
To: Pugliese, Holly <pugliese.holly@epa.gov>
Cc: Good, David <good.david@epa.gov>
Subject: FW: 2020MY Lincoln Aviator PHEV - When will a new 2020 Test Car list be published and application be published on the DIS ?

Holly,

Could you please have the attached MY2020 Test Car List datafile be posted here: https://www.epa.gov/compliance-and-fuel-economy-data/data-cars-used-testing-fuel-economy ? It should replace the existing file for MY2020.

Thank you,

Karen

Karen E. Danzeisen
Information Technology Specialist
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

danzeisen.karen@epa.gov
(734)214-4444
https://www.epa.gov/vehicle-and-engine-certification

Upcoming Out of Office Days: 12/13, 12/20/2019 – 1/3/2020

From: Good, David <good.david@epa.gov>
Sent: Wednesday, December 11, 2019 2:41 PM
To: Danzeisen, Karen <Danzeisen.Karen@epa.gov>
Cc: Stump, Barbara <Stump.Barbara@epa.gov>
Subject: FW: 2020MY Lincoln Aviator PHEV - When will a new 2020 Test Car list be published and application be published on the DIS ?

Karen,

The Lincoln Aviator PHEV was just posted on fe.gov. There will likely be a lot of requests for the FOI application on the DIS and the test car list.

FCA is asking.

When is the next test car list due to be published?

Barbara, Karen says that the DIS is due to be updated this month (Dec 2019). Please make sure the Lincoln Aviator data is included in the next update (test group LFMXT03.03P1).

Thanks

Dave

From: Abeer Windel <abeer.windel@fcagroup.com>
Sent: Wednesday, December 11, 2019 2:20 PM
To: Good, David <good.david@epa.gov>
Subject: Re: fueleconomy.gov - When will a new 2020 Test Car list be published?

Hi Dave,

Both please.

Thanks.

Abeer Windel
FCA US LLC- Chelsea Proving Grounds
Coastdown/Performance/Fuel Economy
Telephone: 734-433-2953
Tieline: 836-2953

On Wed, Dec 11, 2019 at 2:18 PM Good, David <good.david@epa.gov> wrote:

Abeer,

Do you just want the test car list or also the application?

Dave

From: Abeer Windel <abeer.windel@fcagroup.com>
Sent: Wednesday, December 11, 2019 2:04 PM
To: Good, David <good.david@epa.gov>
Subject: fueleconomy.gov - When will a new 2020 Test Car list be published?

Hi Dave,

Do you know when a new 2020 Test Car list data file will be published in <u>fueleconomy.gov</u>? The last time it was posted was in September.

I'm being asked for information on the 2020 Lincoln Aviator PHEV AWD. I see the fuel economy for the vehicle is on the web but the supporting test information hasn't been posted.

Thanks.

Abeer Windel

FCA US LLC- Chelsea Proving Grounds

Coastdown/Performance/Fuel Economy

Telephone: 734-433-2953

Tieline: 836-2953

From: Good, David [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP
(FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=6A0A212FAB8644B89798966A2FFF3AB8-GOOD, DAVID]
Sent: 4/2/2020 8:25:34 PM
To: Snyder, Jim [Snyder.Jim@epa.gov]
CC: Rojeck, Tristin [rojeck.tristin@epa.gov]
Subject: FW: Outside request for the EV Multi-cycle test data for the 2020 Porsche Taycan Turbo S
Attachments: EPA test procedure for EVs-PHEVs-11-14-2017.pdf; image (5).png

Jim,

Can you handle this one? [Although test data is supposed to be releasable (treated as non-CBI)----I would think you may want to check with the Porsche folks before releasing the MCT data for the Taycan.]

Thanks

Dave

From: Mike Reale <Michael.Reale@ihsmarkit.com>
Sent: Thursday, April 2, 2020 3:00 PM
To: Good, David <good.david@epa.gov>
Subject: Question on EV Multi-cycle test data: 2020 Porsche Taycan Turbo S

Hello Dave,

I hope all is well with you and that you are all managing to stay healthy and sane in this crazy, Stay-at-Home time!

I'm not sure if you guys are currently working from home but I thought I'd reach out and see if you can assist at the present time.

My team and I have been doing some analysis on battery electric vehicles and we are most interested in using the data from the EPA EV Multicycle Calculator. Some manufacturers such as Tesla do include this information in their certification applications (screenshot from Tesla's cert app attached for your reference) while Porsche does not include it.

Question: Would it be possible for you to supply this information for the 2020 Porsche Taycan as publicly available information? If you need any formal request to do so (FOI?), let me know, I'd be happy to request in any manner that you need.

Secondly, does the MCT test data supplied to EPA still use the October 2012 version of SAE J1643? I am referencing your helpful EV Test Procedures guide, dated November 2017, and it still calls for using the October 2012 version in your draft summary. But now there is a July 2017 version of SAE J1634 that is the latest version and I believe there are some differences in steady-state speed that could impact the results. So I'm wondering if EPA is still requiring testing using the 2012 SAE standard. And if you have made any recent updates to your EV & PHEV Test procedures summary document, would you mind sending me a copy (I didn't find anything more recent online).

Thanks very much for your help.

Best regards,

Mike
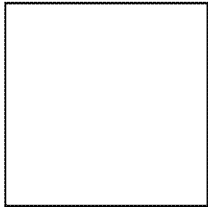
Michael Reale
Associate Director, Global Regulatory Analysis | Automotive
P: +1 313.600.2181
michael.reale@ihsmarkit.com

EPA EV Multicycle Calculator (SAE J1634 Oct 2012)

					As used by EPA laboratory
Manufacturer:	Tesla Inc.				
Carline:	Model 3 Long range				
Model Year	2017			D.Good	March 8, 2016
Vehicle	5YJ3A1E129FR00012				
Test Number	Internal test #				
Comments:					
Lab	NVFEL				
Test Date	6/16/2017				

						Recharge	
Cycle	Energy (Wh)	Distance (mi)	ECdc_cyc	Kuwgt	Kwgt	AC WattHrs	
UDDS1	1515.4594	7.5	202.06	50.52	3.91		89406
UDDS2	1200.0000	7.47	160.64	40.16	52.51		
UDDS3	1155.6000	7.45	155.11	38.78	50.70		
UDDS4	1161.4000	7.45	155.89	38.97	50.96		
HWY1	1790.7000	10.25	174.70	87.35			
HWY2	1738.5000	10.25	169.61	84.80			
SS1	65371.7000	301.26	216.99				
SS2	4336.1000	19.84	218.55				
TOTAL	78269.46	371.470					

K-Factors	UDDS1	UDDS2	UDDS3	UDDS4	HWY1	HWY2
Unweighted	0.250	0.250	0.250	0.250	0.500	0.500
Weighted	0.019	0.327	0.327	0.327	NA	NA

						EPA version
Results	Range (mi)	AC Wh/mi	MPGe	kWh/100mi		kWh/100mi
UDDSu	464.71	192.39				
UDDSw	495.11	180.58	186.6509	18.0578		18.05777
HWY	484.64	196.65	171.3948	19.6651		19.66513

Note:

1. Fill in yellow shaded areas to compute range and AC wh/mi results

2. Weighted results based on SAE J1634 calculations

3. Final values in green shaded area should be rounded to appropriate significant digits

Derating Factor	0.7
Five Cycle Range (mi)	334
MPGe	126
Tesla Desired Range (mi)	310

From:	Good, David [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=6A0A212FAB8644B89798966A2FFF3AB8-GOOD, DAVID]
Sent:	12/11/2019 11:03:41 PM
To:	Deborah A. Zielesch [deborah.a.zielesch@gm.com]
Subject:	RE: 2020 Porsche Taycan Turbo Cert Report
Attachments:	2020 test car list -Dec-11-2019.xlsx

Debbie,

Attached is an advance copy of the Test Car list which will be posted on the web in a couple days.

The DIS will be updated on Monday (12/16) possible---or more likely on Mon (12/23)---so it should have the application, CSI, etc at that time.

Dave

From: Deborah A. Zielesch <deborah.a.zielesch@gm.com>
Sent: Wednesday, December 11, 2019 3:50 PM
To: Good, David <good.david@epa.gov>
Subject: 2020 Porsche Taycan Turbo Cert Report

Dave,

Is any of the Porsche Taycan turbo data available??? Need the certificate summary or any related test data.

Thanks,

Debbie

Deborah Zielesch

General Motors LLC
Passenger Car Fuel Economy Coordinator
Cell Phone: (248) 762-9557
Fax: (248) 685-5604
Compliance & Certification, MC 483-331-500
3300 GM Road, Milford, MI 48380-372

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From: Good, David [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP
(FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=6A0A212FAB8644B89798966A2FFF3AB8-GOOD, DAVID]
Sent: 7/22/2020 5:10:05 PM
To: Moses, Darryl [moses.darryl@epa.gov]
Subject: FW: 2021 FEG Kick-off Call - Agenda and Documents
Attachments: FEG2020_text.docx; 2021 FEG Timeline-w-headers-from Janet-7-21-2020.pdf

Darryl,

Sorry about the late notice for today's 3PM conf call. Here's the agenda.

Stay safe

Dave

> Ex. 6 Personal Privacy (PP)

From: Hopson, Janet <hopsonjl@ornl.gov>
Sent: Tuesday, July 21, 2020 1:07 PM
To: Bluestein, Linda <linda.bluestein@ee.doe.gov>; Bunker, Amy <Bunker.Amy@epa.gov>; Dafoe, Wendy
<wendy.dafoe@nrel.gov>; Gibson, Robert <gibsonrc@ornl.gov>; Good, David <good.david@epa.gov>; Pugliese, Holly
<pugliese.holly@epa.gov>; 'Smith, Dennis' <dennis.a.smith@ee.doe.gov>; Wehrly, Linc <wehrly.linc@epa.gov>;
Zaremski, Sara <zaremski.sara@epa.gov>; Rojeck, Tristin <rojeck.tristin@epa.gov>; Davis, Stacy <davissc@ornl.gov>;
Graff, Michelle <graff.michelle@epa.gov>; Kimball, Joshua <kimball.joshua@epa.gov>
Subject: 2021 FEG Kick-off Call - Agenda and Documents

Hello Everyone:

Reminder: We will have our first FEG call this Wednesday at 3:00 PM.

Attached is the proposed timeline for the 2021 FEG along with a with a word file containing the 2020 FEG Text. We have
not yet updated the graphics, fuel prices, number of alternative fueling stations, etc. Also, the conversion to word isn't
perfect so some of the text may not line up as in the actual guide.

Below is the agenda + call-in information. Please let me know if you would like to add anything to the agenda.

Tentative Agenda
1.   2021 Timeline – Key dates
2.   Request Text Review/Comments
3.   Cover Suggestions
4.   Schedule for next call

Dial:
Enter > Ex. 6 Personal Privacy (PP)

Best Regards,

Janet

Janet L. Hopson
Research Associate Professor, Department of Earth and Planetary Sciences
The University of Tennessee
National Transportation Research Center
2360 Cherahala Blvd
Knoxville, TN 37932
Phone: 865-201-3969
hopsonjl@ornl.gov

From:	Good, David [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=6A0A212FAB8644B89798966A2FFF3AB8-GOOD, DAVID]
Sent:	7/10/2020 12:33:53 PM
To:	Rojeck, Tristin [rojeck.tristin@epa.gov]
Subject:	FW: 0.7 adjustment factor
Attachments:	Briefing for Karl-2009_FE_Labels_for_EVs_&_Fuel_Cell_Vehs-Update5.008.ppt; 2009 FE Label Calcs for EVs & Fuel Cell Vehs.708.ppt; Addl slides for GM - In-use FE adjustment.n08.ppt; electricvehiclelabeling3--9-25-08.doc

Tristin,

I found the 2008 background for the 0.7 adjustment factor----on my home computer. [This was before we had laptops and I used to work on EPA files on my personal computer at home.]

The "Briefing for Karl" presentation is the final one---which has all the logic, recommendations, etc.

Dave

From: David Good <dgood999@comcast.net>
Sent: Friday, July 10, 2020 8:27 AM
To: Good, David <good.david@epa.gov>
Subject: 0.7 adjustment factor

From:	Danzeisen, Karen [Danzeisen.Karen@epa.gov]
Sent:	10/27/2020 3:40:11 PM
To:	Hopson, Janet [hopsonjl@ornl.gov]
CC:	Richardson, Jacquelyn [flukerjf@ornl.gov]; Kenausis, Kristin [Kenausis.Kristin@epa.gov]; Good, David [good.david@epa.gov]; Rojeck, Tristin [rojeck.tristin@epa.gov]; Moses, Darryl [moses.darryl@epa.gov]
Subject:	Updated 2020/2021 GVG/SmartWay data and downloadable files for posting
Attachments:	all-alpha-20 2020-10-26.txt; all-alpha-21 2020-10-26.txt; all-alpha-21 2020-10-26.pdf; all-alpha-21 2020-10-26.xlsx; all-alpha-20 2020-10-26.pdf; all-alpha-20 2020-10-26.xlsx; 2021EMSN_FE_RANK_FOR_DOE 2020-10-26.txt; 2020EMSN_FE_RANK_FOR_DOE 2020-10-26.txt; grand_model 2020-10-26.txt

Hello Janet,

   I have processed Model Years 2020 and 2021 GVG/SmartWay data updates and the resulting base data (2) and downloadable files (6) are attached. Please replace the existing Fueleconomy.gov data and files with these at your earliest convenience.

Thank you,
Karen

Karen E. Danzeisen
Information Technology Specialist
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

danzeisen.karen@epa.gov
(734)214-4444
https://www.epa.gov/vehicle-and-engine-certification

Model Year 2021 Green Vehicle Guide

(Limited to releasable data submitted to EPA on or earlier than 10/26/2020)*

Model	Displ	Cyl	Trans	Drive	Fuel	Cert Region	Stnd	Stnd Description	Underhood ID	Veh Class	Air Pollution Score	City MPG	Hwy MPG	Cmb MPG	Greenhouse Gas Score	SmartWay	Comb CO2
ACURA ILX	2.4	4	AMS-8	2WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	MHNXV02.4KH3	small car	3	24	34	28	6	No	316
ACURA ILX	2.4	4	AMS-8	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	MHNXV02.4KH3	small car	3	24	34	28	6	No	316
ACURA RDX	2	4	SemiAuto-10	2WD	Gasoline	CA	L3ULEV50	California LEV-III ULEV50	MHNXT02.08VC	small SUV	6	22	28	24	5	No	370
ACURA RDX	2	4	SemiAuto-10	2WD	Gasoline	FA	T3B50	Federal Tier 3 Bin 50	MHNXT02.08VC	small SUV	6	22	28	24	5	No	370
ACURA RDX	2	4	SemiAuto-10	4WD	Gasoline	CA	L3ULEV50	California LEV-III ULEV50	MHNXT02.08VC	small SUV	6	21	27	23	5	No	385
ACURA RDX	2	4	SemiAuto-10	4WD	Gasoline	FA	T3B50	Federal Tier 3 Bin 50	MHNXT02.08VC	small SUV	6	21	27	23	5	No	385
ACURA RDX A-SPEC	2	4	SemiAuto-10	2WD	Gasoline	CA	L3ULEV50	California LEV-III ULEV50	MHNXT02.09VC	small SUV	6	22	27	24	5	No	375
ACURA RDX A-SPEC	2	4	SemiAuto-10	2WD	Gasoline	FA	T3B50	Federal Tier 3 Bin 50	MHNXT02.09VC	small SUV	6	22	27	24	5	No	375
ACURA RDX A-SPEC	2	4	SemiAuto-10	4WD	Gasoline	CA	L3ULEV50	California LEV-III ULEV50	MHNXT02.09VC	small SUV	6	21	26	23	5	No	387
ACURA RDX A-SPEC	2	4	SemiAuto-10	4WD	Gasoline	FA	T3B50	Federal Tier 3 Bin 50	MHNXT02.09VC	small SUV	6	21	26	23	5	No	387
ACURA TLX	2	4	SemiAuto-10	2WD	Gasoline	CA	L3SULEV30	California LEV-III SULEV30	MHNXV02.0AEC	small car	7	22	31	25	5	No	352
ACURA TLX	2	4	SemiAuto-10	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	MHNXV02.0AEC	small car	7	22	31	25	5	No	352
ACURA TLX	2	4	SemiAuto-10	4WD	Gasoline	CA	L3SULEV30	California LEV-III SULEV30	MHNXV02.0AEC	small car	7	21	29	24	5	No	369
ACURA TLX	2	4	SemiAuto-10	4WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	MHNXV02.0AEC	small car	7	21	29	24	5	No	369
ACURA TLX AWD A-SPEC	2	4	SemiAuto-10	4WD	Gasoline	CA	L3SULEV30	California LEV-III SULEV30	MHNXV02.0AEC	small car	7	21	29	24	5	No	371
ACURA TLX AWD A-SPEC	2	4	SemiAuto-10	4WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	MHNXV02.0AEC	small car	7	21	29	24	5	No	371
ACURA TLX FWD A-SPEC	2	4	SemiAuto-10	2WD	Gasoline	CA	L3SULEV30	California LEV-III SULEV30	MHNXV02.0AEC	small car	7	22	30	25	5	No	357
ACURA TLX FWD A-SPEC	2	4	SemiAuto-10	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	MHNXV02.0AEC	small car	7	22	30	25	5	No	357
ALFA ROMEO Giulia	2	4	Auto-8	2WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	MCRXJ02.05P2	midsize car	3	24	33	27	6	No	330
ALFA ROMEO Giulia	2	4	Auto-8	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	MCRXJ02.05P2	midsize car	3	24	33	27	6	No	330
ALFA ROMEO Giulia AWD	2	4	Auto-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	MCRXJ02.05P2	midsize car	3	23	31	26	5	No	348
ALFA ROMEO Giulia AWD	2	4	Auto-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	MCRXJ02.05P2	midsize car	3	23	31	26	5	No	348
ALFA ROMEO Stelvio	2	4	Auto-8	2WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	MCRXJ02.05P2	small SUV	3	22	29	25	5	No	359
ALFA ROMEO Stelvio	2	4	Auto-8	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	MCRXJ02.05P2	small SUV	3	22	29	25	5	No	359
ALFA ROMEO Stelvio AWD	2	4	Auto-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	MCRXJ02.05P2	small SUV	3	22	28	24	5	No	364
ALFA ROMEO Stelvio AWD	2	4	Auto-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	MCRXJ02.05P2	small SUV	3	22	28	24	5	No	364
ASTON MARTIN DB11 V12	5.2	12	SemiAuto-8	2WD	Gasoline	CA	L2ULEV125	California LEV-II ULEV125	MASXV05.2AM5	small car	3	15	22	18	3	No	497
ASTON MARTIN DB11 V12	5.2	12	SemiAuto-8	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	MASXV05.2AM5	small car	3	15	22	18	3	No	497
ASTON MARTIN DB11 V8	4	8	SemiAuto-8	2WD	Gasoline	CA	L2ULEV125	California LEV-II ULEV125	MASXV04.0AES	small car	3	18	24	20	4	No	431
ASTON MARTIN DB11 V8	4	8	SemiAuto-8	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	MASXV04.0AES	small car	3	18	24	20	4	No	431
ASTON MARTIN DBS	5.2	12	SemiAuto-8	2WD	Gasoline	CA	L2ULEV125	California LEV-II ULEV125	MASXV05.2AM5	small car	3	14	22	17	3	No	522
ASTON MARTIN DBS	5.2	12	SemiAuto-8	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	MASXV05.2AM5	small car	3	14	22	17	3	No	522
ASTON MARTIN DBX V8	4	8	Auto-9	4WD	Gasoline	CA	L2ULEV125	California LEV-II ULEV125	MASXJ04.0AEX	standard SUV	3	14	18	15	2	No	572
ASTON MARTIN DBX V8	4	8	Auto-9	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	MASXJ04.0AEX	standard SUV	3	14	18	15	2	No	572
ASTON MARTIN Vantage	4	8	SemiAuto-8	2WD	Gasoline	CA	L2ULEV125	California LEV-II ULEV125	MASXV04.0AES	small car	3	18	24	20	4	No	435
ASTON MARTIN Vantage	4	8	SemiAuto-8	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	MASXV04.0AES	small car	3	18	24	20	4	No	435
ASTON MARTIN Vantage Manual	4	8	Man-7	2WD	Gasoline	CA	L2ULEV125	California LEV-II ULEV125	MASXV04.0AES	small car	3	14	21	17	3	No	541
ASTON MARTIN Vantage Manual	4	8	Man-7	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	MASXV04.0AES	small car	3	14	21	17	3	No	541
AUDI A4	2	4	AMS-7	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	MVGAV02.0A7E	small car	5	25	34	28	6	No	311
AUDI A4	2	4	AMS-7	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	MVGAV02.0A7E	small car	5	25	34	28	6	No	311
AUDI A4 S line quattro	2	4	AMS-7	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	MVGAJ02.0A7G	small car	5	24	31	27	6	No	331

*Vehicles may be added throughout the model year. Please check back for updates.

Model Year 2021 Green Vehicle Guide

(Limited to releasable data submitted to EPA on or earlier than 10/26/2020)*

Model	Displ	Cyl	Trans	Drive	Fuel	Cert Region	Stnd	Stnd Description	Underhood ID	Veh Class	Air Pollution Score	City MPG	Hwy MPG	Cmb MPG	Greenhouse Gas Score	SmartWay	Comb CO2
AUDI A4 S line quattro	2	4	AMS-7	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	MVGAJ02.0A7G	small car	5	24	31	27	6	No	331
AUDI A4 allroad quattro	2	4	AMS-7	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	MVGAJ02.0A7G	station wagon	5	24	30	26	5	No	335
AUDI A4 allroad quattro	2	4	AMS-7	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	MVGAJ02.0A7G	station wagon	5	24	30	26	5	No	335
AUDI A5	2	4	AMS-7	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	MVGAJ02.0A7G	small car	5	24	31	27	6	No	331
AUDI A5	2	4	AMS-7	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	MVGAJ02.0A7G	small car	5	24	31	27	6	No	331
AUDI A5 Cabriolet	2	4	AMS-7	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	MVGAJ02.0A7G	small car	5	23	31	26	5	No	341
AUDI A5 Cabriolet	2	4	AMS-7	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	MVGAJ02.0A7G	small car	5	23	31	26	5	No	341
AUDI A5 Sportback S line quattro	2	4	AMS-7	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	MVGAJ02.0A7G	midsize car	5	24	31	27	6	No	331
AUDI A5 Sportback S line quattro	2	4	AMS-7	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	MVGAJ02.0A7G	midsize car	5	24	31	27	6	No	331
AUDI A5 Sportback quattro	2	4	AMS-7	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	MVGAV02.0A7E	midsize car	5	25	34	28	6	No	311
AUDI A5 Sportback quattro	2	4	AMS-7	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	MVGAV02.0A7E	midsize car	5	25	34	28	6	No	311
AUDI A6	2	4	AMS-7	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	MVGAJ02.0A7G	midsize car	5	23	31	26	5	No	341
AUDI A6	2	4	AMS-7	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	MVGAJ02.0A7G	midsize car	5	23	31	26	5	No	341
AUDI A6	2	4	AMS-7	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	MVGAV02.0A7M	midsize car	5	23	31	26	5	No	341
AUDI A6	2	4	AMS-7	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	MVGAV02.0A7M	midsize car	5	23	31	26	5	No	341
AUDI A6	3	6	AMS-7	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	MVGAV03.0N7N	midsize car	5	22	29	24	5	No	364
AUDI A6	3	6	AMS-7	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	MVGAV03.0N7N	midsize car	5	22	29	24	5	No	364
AUDI A6 Allroad	3	6	AMS-7	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	MVGAV03.0N7N	station wagon	5	20	26	22	4	No	398
AUDI A6 Allroad	3	6	AMS-7	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	MVGAV03.0N7N	station wagon	5	20	26	22	4	No	398
AUDI A7	2	4	AMS-7	4WD	Gasoline/Electricity	CA	L3SULEV30	California LEV-III SULEV30	MVGAJ02.0A3P	midsize car	7	26/64	34/74	29/68	10	Yes	139
AUDI A7	2	4	AMS-7	4WD	Gasoline/Electricity	FA	T3B30	Federal Tier 3 Bin 30	MVGAJ02.0A3P	midsize car	7	26/64	34/74	29/68	10	Yes	139
AUDI A7	3	6	AMS-7	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	MVGAV03.0N7N	midsize car	5	22	29	24	5	No	364
AUDI A7	3	6	AMS-7	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	MVGAV03.0N7N	midsize car	5	22	29	24	5	No	364
AUDI A8 L	3	6	SemiAuto-8	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	MVGAV03.0N7R	large car	5	17	26	21	4	No	430
AUDI A8 L	3	6	SemiAuto-8	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	MVGAV03.0N7R	large car	5	17	26	21	4	No	430
AUDI A8 L	3	6	SemiAuto-8	4WD	Gasoline/Electricity	CA	L3ULEV125	California LEV-III ULEV125	MVGAV03.0NAP	large car	3	21/49	26/60	23/53	8	No	213
AUDI A8 L	3	6	SemiAuto-8	4WD	Gasoline/Electricity	FA	T3B125	Federal Tier 3 Bin 125	MVGAV03.0NAP	large car	3	21/49	26/60	23/53	8	No	213
AUDI A8 L	4	8	SemiAuto-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	MVGAJ04.0NAT	large car	3	15	23	18	3	No	495
AUDI A8 L	4	8	SemiAuto-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	MVGAJ04.0NAT	large car	3	15	23	18	3	No	495
AUDI Q3	2	4	SemiAuto-8	4WD	Gasoline	CA	L3SULEV30	California LEV-III SULEV30	MVGAJ02.0A3T	small SUV	7	20	28	23	5	No	384
AUDI Q3	2	4	SemiAuto-8	4WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	MVGAJ02.0A3T	small SUV	7	20	28	23	5	No	384
AUDI Q5	2	4	AMS-7	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	MVGAJ02.0A7G	small SUV	5	23	28	25	5	No	349
AUDI Q5	2	4	AMS-7	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	MVGAJ02.0A7G	small SUV	5	23	28	25	5	No	349

*Vehicles may be added throughout the model year. Please check back for updates.

Model	Displ	Cyl	Trans	Drive	Fuel	Cert Region	Stnd	Stnd Description	Underhood ID	Veh Class	Air Pollution Score	City MPG	Hwy MPG	Cmb MPG	Greenhouse Gas Score	SmartWay	Comb CO2
AUDI Q7	2	4	SemiAuto-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	MVGAT02.0AA7	standard SUV	3	19	23	21	4	No	425
AUDI Q7	2	4	SemiAuto-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	MVGAT02.0AA7	standard SUV	3	19	23	21	4	No	425
AUDI Q7	3	6	SemiAuto-8	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	MVGAT03.0N7M	standard SUV	5	18	23	20	4	No	453
AUDI Q7	3	6	SemiAuto-8	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	MVGAT03.0N7M	standard SUV	5	18	23	20	4	No	453
AUDI Q8	3	6	SemiAuto-8	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	MVGAT03.0N7M	standard SUV	5	18	23	20	4	No	453
AUDI Q8	3	6	SemiAuto-8	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	MVGAT03.0N7M	standard SUV	5	18	23	20	4	No	453
AUDI R8	5.2	10	AMS-7	2WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	MVGAV05.2NBE	small car	1	14	23	17	3	No	528
AUDI R8	5.2	10	AMS-7	2WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	MVGAV05.2NBE	small car	1	14	23	17	3	No	528
AUDI R8	5.2	10	AMS-7	4WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	MVGAV05.2NBE	small car	1	13	20	16	2	No	567
AUDI R8	5.2	10	AMS-7	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	MVGAV05.2NBE	small car	1	13	20	16	2	No	567
AUDI R8 Spyder	5.2	10	AMS-7	2WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	MVGAV05.2NBE	small car	1	14	23	17	3	No	528
AUDI R8 Spyder	5.2	10	AMS-7	2WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	MVGAV05.2NBE	small car	1	14	23	17	3	No	528
AUDI R8 Spyder	5.2	10	AMS-7	4WD	Gasoline	CA	L3LEV160	California LEV-III LEV160	MVGAV05.2NBE	small car	1	13	20	16	2	No	567
AUDI R8 Spyder	5.2	10	AMS-7	4WD	Gasoline	FA	T3B160	Federal Tier 3 Bin 160	MVGAV05.2NBE	small car	1	13	20	16	2	No	567
AUDI RS 5	2.9	6	SemiAuto-8	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	MVGAV02.9N7B	small car	5	18	25	20	4	No	432
AUDI RS 5	2.9	6	SemiAuto-8	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	MVGAV02.9N7B	small car	5	18	25	20	4	No	432
AUDI RS 5 Sportback	2.9	6	SemiAuto-8	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	MVGAV02.9N7B	midsize car	5	18	25	21	4	No	428
AUDI RS 5 Sportback	2.9	6	SemiAuto-8	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	MVGAV02.9N7B	midsize car	5	18	25	21	4	No	428
AUDI RS 6 Avant	4	8	SemiAuto-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	MVGAJ04.0NAT	station wagon	3	15	22	17	3	No	514
AUDI RS 6 Avant	4	8	SemiAuto-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	MVGAJ04.0NAT	station wagon	3	15	22	17	3	No	514
AUDI RS 7	4	8	SemiAuto-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	MVGAJ04.0NAT	midsize car	3	15	22	17	3	No	507
AUDI RS 7	4	8	SemiAuto-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	MVGAJ04.0NAT	midsize car	3	15	22	17	3	No	507
AUDI RS Q8	4	8	SemiAuto-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	MVGAJ04.0NAT	standard SUV	3	13	19	15	2	No	579
AUDI RS Q8	4	8	SemiAuto-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	MVGAJ04.0NAT	standard SUV	3	13	19	15	2	No	579
AUDI S4	3	6	SemiAuto-8	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	MVGAJ03.0N7F	small car	5	20	28	23	5	No	380
AUDI S4	3	6	SemiAuto-8	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	MVGAJ03.0N7F	small car	5	20	28	23	5	No	380
AUDI S5	3	6	SemiAuto-8	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	MVGAJ03.0N7F	small car	5	20	28	23	5	No	380
AUDI S5	3	6	SemiAuto-8	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	MVGAJ03.0N7F	small car	5	20	28	23	5	No	380
AUDI S5 Cabriolet	3	6	SemiAuto-8	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	MVGAJ03.0N7F	small car	5	20	26	22	4	No	393
AUDI S5 Cabriolet	3	6	SemiAuto-8	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	MVGAJ03.0N7F	small car	5	20	26	22	4	No	393
AUDI S5 Sportback	3	6	SemiAuto-8	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	MVGAJ03.0N7F	midsize car	5	20	28	23	5	No	380
AUDI S5 Sportback	3	6	SemiAuto-8	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	MVGAJ03.0N7F	midsize car	5	20	28	23	5	No	380
AUDI S6	2.9	6	SemiAuto-8	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	MVGAV02.9N7S	midsize car	5	18	28	22	4	No	410
AUDI S6	2.9	6	SemiAuto-8	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	MVGAV02.9N7S	midsize car	5	18	28	22	4	No	410
AUDI S7	2.9	6	SemiAuto-8	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	MVGAV02.9N7S	midsize car	5	18	28	22	4	No	410

Model	Displ	Cyl	Trans	Drive	Fuel	Cert Region	Stnd	Stnd Description	Underhood ID	Veh Class	Air Pollution Score	City MPG	Hwy MPG	Cmb MPG	Greenhouse Gas Score	SmartWay	Comb CO2
AUDI S7	2.9	6	SemiAuto-8	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	MVGAV02.9N7S	midsize car	5	18	28	22	4	No	410
AUDI S8	4	8	SemiAuto-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	MVGAJ04.0NAT	large car	3	13	22	16	2	No	545
AUDI S8	4	8	SemiAuto-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	MVGAJ04.0NAT	large car	3	13	22	16	2	No	545
AUDI SQ5	3	6	SemiAuto-8	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	MVGAJ03.0N7F	small SUV	5	18	24	20	4	No	441
AUDI SQ5	3	6	SemiAuto-8	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	MVGAJ03.0N7F	small SUV	5	18	24	20	4	No	441
AUDI SQ7	4	8	SemiAuto-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	MVGAT04.0NAV	standard SUV	3	15	21	17	3	No	522
AUDI SQ7	4	8	SemiAuto-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	MVGAT04.0NAV	standard SUV	3	15	21	17	3	No	522
AUDI SQ8	4	8	SemiAuto-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	MVGAT04.0NAV	standard SUV	3	15	21	17	3	No	522
AUDI SQ8	4	8	SemiAuto-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	MVGAT04.0NAV	standard SUV	3	15	21	17	3	No	522
AUDI TT Coupe	2	4	AMS-7	4WD	Gasoline	CA	L3SULEV30	California LEV-III SULEV30	MVGAJ02.0A3T	small car	7	23	31	26	5	No	344
AUDI TT Coupe	2	4	AMS-7	4WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	MVGAJ02.0A3T	small car	7	23	31	26	5	No	344
AUDI TT RS	2.5	5	AMS-7	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	MVGAV02.5NAG	small car	3	20	30	24	5	No	373
AUDI TT RS	2.5	5	AMS-7	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	MVGAV02.5NAG	small car	3	20	30	24	5	No	373
AUDI TT Roadster	2	4	AMS-7	4WD	Gasoline	CA	L3SULEV30	California LEV-III SULEV30	MVGAJ02.0A3T	small car	7	23	31	26	5	No	344
AUDI TT Roadster	2	4	AMS-7	4WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	MVGAJ02.0A3T	small car	7	23	31	26	5	No	344
AUDI e-tron	N/A	N/A	Auto-1	4WD	Electricity	FA	T3B0	Federal Tier 3 Bin 0	MVGAT00.0AZE	standard SUV	10	78	77	78	10	Elite	0
AUDI e-tron	N/A	N/A	Auto-1	4WD	Electricity	CA	ZEV	California ZEV	MVGAT00.0AZE	standard SUV	10	78	77	78	10	Elite	0
AUDI e-tron Sportback	N/A	N/A	Auto-1	4WD	Electricity	FA	T3B0	Federal Tier 3 Bin 0	MVGAT00.0AZE	standard SUV	10	76	78	77	10	Elite	0
AUDI e-tron Sportback	N/A	N/A	Auto-1	4WD	Electricity	CA	ZEV	California ZEV	MVGAT00.0AZE	standard SUV	10	76	78	77	10	Elite	0
BENTLEY Bentayga	4	8	SemiAuto-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	MVGAT04.0PAA	standard SUV	3	15	24	18	3	No	497
BENTLEY Bentayga	4	8	SemiAuto-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	MVGAT04.0PAA	standard SUV	3	15	24	18	3	No	497
BENTLEY Continental GT	6	12	AMS-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	MVGAV06.0EAR	small car	3	12	20	15	2	No	586
BENTLEY Continental GT	6	12	AMS-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	MVGAV06.0EAR	small car	3	12	20	15	2	No	586
BENTLEY Continental GT Convertible	4	8	AMS-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	MVGAV04.0PAA	small car	3	16	26	19	3	No	468
BENTLEY Continental GT Convertible	4	8	AMS-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	MVGAV04.0PAA	small car	3	16	26	19	3	No	468
BENTLEY Continental GT Convertible	6	12	AMS-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	MVGAV06.0EAR	small car	3	12	19	15	2	No	601
BENTLEY Continental GT Convertible	6	12	AMS-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	MVGAV06.0EAR	small car	3	12	19	15	2	No	601
BENTLEY Flying Spur	6	12	AMS-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	MVGAV06.0EAR	midsize car	3	12	19	15	2	No	601
BENTLEY Flying Spur	6	12	AMS-8	4WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	MVGAV06.0EAR	midsize car	3	12	19	15	2	No	601
BMW 228i xDrive Gran Coupe	2	4	SemiAuto-8	4WD	Gasoline	CA	L3SULEV30	California LEV-III SULEV30	MBMXJ02.0B4X	small car	7	23	33	27	6	No	332

*Vehicles may be added throughout the model year. Please check back for updates.

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(Limited to releasable data submitted to EPA on or earlier than 10/26/2020)*

Model	Displ	Cyl	Trans	Drive	Fuel	Cert Region	Stnd	Stnd Description	Underhood ID	Veh Class	Air Pollution Score	City MPG	Hwy MPG	Cmb MPG	Greenhouse Gas Score	SmartWay	Comb CO2
BMW 228i xDrive Gran Coupe	2	4	SemiAuto-8	4WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	MBMXJ02.0B4X	small car	7	23	33	27	6	No	332
BMW 230i Convertible	2	4	SemiAuto-8	2WD	Gasoline	CA	L3SULEV30	California LEV-III SULEV30	MBMXJ02.0B4X	small car	7	23	33	27	6	No	333
BMW 230i Convertible	2	4	SemiAuto-8	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	MBMXJ02.0B4X	small car	7	23	33	27	6	No	333
BMW 230i Coupe	2	4	Man-6	2WD	Gasoline	CA	L3SULEV30	California LEV-III SULEV30	MBMXJ02.0B4X	small car	7	21	32	25	5	No	356
BMW 230i Coupe	2	4	Man-6	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	MBMXJ02.0B4X	small car	7	21	32	25	5	No	356
BMW 230i Coupe	2	4	SemiAuto-8	2WD	Gasoline	CA	L3SULEV30	California LEV-III SULEV30	MBMXJ02.0B4X	small car	7	25	32	28	6	No	321
BMW 230i Coupe	2	4	SemiAuto-8	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	MBMXJ02.0B4X	small car	7	25	32	28	6	No	321
BMW 230i xDrive Coupe	2	4	SemiAuto-8	4WD	Gasoline	CA	L3SULEV30	California LEV-III SULEV30	MBMXJ02.0B4X	small car	7	21	30	24	5	No	366
BMW 230i xDrive Coupe	2	4	SemiAuto-8	4WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	MBMXJ02.0B4X	small car	7	21	30	24	5	No	366
BMW 330e	2	4	SemiAuto-8	2WD	Gasoline/Electricity	CA	L3SULEV30	California LEV-III SULEV30	MBMXJ02.0H30	small car	7	25/72	33/80	28/75	10	Yes	160
BMW 330e	2	4	SemiAuto-8	2WD	Gasoline/Electricity	FA	T3B30	Federal Tier 3 Bin 30	MBMXJ02.0H30	small car	7	25/72	33/80	28/75	10	Yes	160
BMW 330e	2	4	SemiAuto-8	4WD	Gasoline/Electricity	CA	L3SULEV30	California LEV-III SULEV30	MBMXJ02.0H30	small car	7	22/64	30/71	25/67	9	Yes	192
BMW 330e	2	4	SemiAuto-8	4WD	Gasoline/Electricity	FA	T3B30	Federal Tier 3 Bin 30	MBMXJ02.0H30	small car	7	22/64	30/71	25/67	9	Yes	192
BMW 330i	2	4	SemiAuto-8	2WD	Gasoline	CA	L3SULEV30	California LEV-III SULEV30	MBMXJ02.0B4X	small car	7	26	36	30	6	No	298
BMW 330i	2	4	SemiAuto-8	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	MBMXJ02.0B4X	small car	7	26	36	30	6	No	298
BMW 330i	2	4	SemiAuto-8	4WD	Gasoline	CA	L3SULEV30	California LEV-III SULEV30	MBMXJ02.0B4X	small car	7	25	34	28	6	No	313
BMW 330i	2	4	SemiAuto-8	4WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	MBMXJ02.0B4X	small car	7	25	34	28	6	No	313
BMW 430i Coupe	2	4	SemiAuto-8	2WD	Gasoline	CA	L3SULEV30	California LEV-III SULEV30	MBMXJ02.0B4X	small car	7	26	34	29	6	No	304
BMW 430i Coupe	2	4	SemiAuto-8	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	MBMXJ02.0B4X	small car	7	26	34	29	6	No	304
BMW 430i Coupe	2	4	SemiAuto-8	4WD	Gasoline	CA	L3SULEV30	California LEV-III SULEV30	MBMXJ02.0B4X	small car	7	24	33	27	6	No	325
BMW 430i Coupe	2	4	SemiAuto-8	4WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	MBMXJ02.0B4X	small car	7	24	33	27	6	No	325
BMW 530e	2	4	SemiAuto-8	2WD	Gasoline/Electricity	CA	L3SULEV30	California LEV-III SULEV30	MBMXJ02.0H30	small car	7	24/59	29/72	26/64	9	Yes	178
BMW 530e	2	4	SemiAuto-8	2WD	Gasoline/Electricity	FA	T3B30	Federal Tier 3 Bin 30	MBMXJ02.0H30	small car	7	24/59	29/72	26/64	9	Yes	178
BMW 530e	2	4	SemiAuto-8	4WD	Gasoline/Electricity	CA	L3SULEV30	California LEV-III SULEV30	MBMXJ02.0H30	small car	7	22/59	28/67	25/62	9	Yes	203
BMW 530e	2	4	SemiAuto-8	4WD	Gasoline/Electricity	FA	T3B30	Federal Tier 3 Bin 30	MBMXJ02.0H30	small car	7	22/59	28/67	25/62	9	Yes	203
BMW 530i	2	4	SemiAuto-8	2WD	Gasoline	CA	L3SULEV30	California LEV-III SULEV30	MBMXJ02.0B4X	midsize car	7	25	33	28	6	No	313
BMW 530i	2	4	SemiAuto-8	2WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	MBMXJ02.0B4X	midsize car	7	25	33	28	6	No	313
BMW 530i	2	4	SemiAuto-8	4WD	Gasoline	CA	L3SULEV30	California LEV-III SULEV30	MBMXJ02.0B4X	midsize car	7	23	32	27	6	No	330
BMW 530i	2	4	SemiAuto-8	4WD	Gasoline	FA	T3B30	Federal Tier 3 Bin 30	MBMXJ02.0B4X	midsize car	7	23	32	27	6	No	330
BMW 540i	3	6	SemiAuto-8	2WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	MBMXV03.0G2X	midsize car	5	25	32	27	6	No	322
BMW 540i	3	6	SemiAuto-8	2WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	MBMXV03.0G2X	midsize car	5	25	32	27	6	No	322
BMW 540i	3	6	SemiAuto-8	4WD	Gasoline	CA	L3ULEV70	California LEV-III ULEV70	MBMXV03.0G2X	midsize car	5	23	31	26	5	No	337
BMW 540i	3	6	SemiAuto-8	4WD	Gasoline	FA	T3B70	Federal Tier 3 Bin 70	MBMXV03.0G2X	midsize car	5	23	31	26	5	No	337
BMW 740i	3	6	SemiAuto-8	2WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	MBMXJ03.0B07	large car	3	22	29	25	5	No	360
BMW 740i	3	6	SemiAuto-8	2WD	Gasoline	FA	T3B125	Federal Tier 3 Bin 125	MBMXJ03.0B07	large car	3	22	29	25	5	No	360
BMW 740i	3	6	SemiAuto-8	4WD	Gasoline	CA	L3ULEV125	California LEV-III ULEV125	MBMXJ03.0B07	large car	3	20	27	23	5	No	387

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